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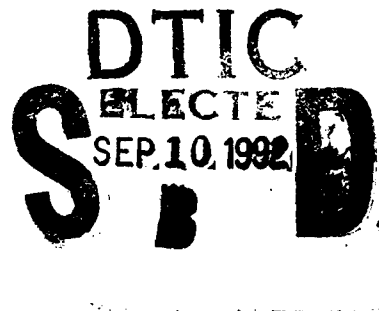June 1992

ARC DIGITAL RASTER IMAGERY EVALUATION

Synectics Corporation

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Rome Laboratory
Air Force Systems Command
Griffiss Air Force Base, NY 13441-5700

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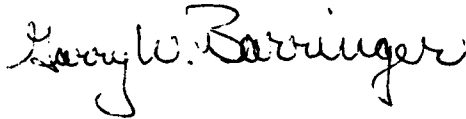RL-TR-92-154 has been reviewed and is approved for publication.

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13. ABSTRACT (Maximum 200 words)

The ARC Digital Raster Imagery (ADRI) evaluation process was an evaluation of the absolute horizontal and vertical accuracy of the ADRI product. Both absolute and relative horizontal evaluation activities employed the same statistical measures for the analysis, namely: the mean error in latitude and longitude; standard deviations of the errors in latitude and longitude; the root mean square of the errors for latitude and longitude; and the average error for latitude and longitude. The vertical accuracy analysis employed mean height error; standard deviation of the height errors; RMS of the height errors and average height error.

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SECTION 1. INTRODUCTION

This document is the Final Technical Report (FTR) for the ARC Digital Raster Imagery (ADRI) Evaluation Task.

1.1 IDENTIFICATION

This task is the ARC Digital Raster Imagery Evaluation task. The ADRI Evaluation task is task #5 under the IRR Task Ordering Agreement (TOA), Contract Number F30602-91-D-0003/0005, for Rome Laboratory, Griffiss Air Force Base, New York. The work on this task was done by Synectics Corporation as the prime contractor, and by TRIFID Corporation as a subcontractor. The Laboratory Program Manager (LPM) for this task is Mr. James A. Sieffert, RL/IRRP.

1.2 ADRI EVALUATION OBJECTIVES

The objectives for the ADRI Evaluation task were to provide an evaluation of government-furnished ADRI geocells to determine attainable point positioning accuracies, and to provide a processing capability to generate the ADRI product from SPOT 1A, LANDSAT Thematic Mapper, Digital Point Positioning Data Base, National High Altitude Photography (NHAP), reconnaissance images, and digitized paper maps. The multiple source ADRI generation capability produces a set of ADRI products which will be referenced as the Variety Pack in this report.

1.3 SCOPE OF THE ADRI EVALUATION TASK

The scope of the ADRI Evaluation included the following technical requirements:

√ Provide an evaluation of 15 government-furnished geocells of ADRI data.

- Determine the point position accuracies defined by horizontal Circular Error (CE) radius at a 90% confidence level, and vertical Linear Error (LE) at a 90% confidence level.

- Determine the CE and LE measures for Relative and Absolute point positioning.

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- The evaluation sample will consist of at least four (4) mensurated points per geocell.

- Document the methods and results in the Final Technical Report.

√ Perform processing of government-provided SPOT 1A imagery utilizing Digital Terrain Elevation Data (DTED) and ground control geopositions to produce the ADRI product.

√ Perform processing of additional government-provided imagery to produce the ADRI product. The additional imagery included:

- Two LANDSAT Thematic Mapper scenes.
- Two digitized Point Positioning Data Base(PPDB) images.
- A single National High Altitude Photography (NHAP).
- Two reconnaissance images.
- A single digitized paper map.
- A single merged SPOT Pan/LANDSAT TM scene.

√ Deliver the software and data to the government.

1.4 DOCUMENT OVERVIEW

This document will include the report on the first task, which is the ADRI evaluation process. Section 3 of this volume presents the characteristics of the data, the interpretation of the statistics used in the analysis, and the methods employed for analysis. Section 4 presents the results of the analysis.

The ADRI processing capability and the Variety Pack generation will be presented in an unpublished document which will be retained as an internal document by Rome Laboratory/IRRP.

SECTION 2. REFERENCES

This section contains the following sections:

√ Government Documents
√ Non-government Documents

2.1 GOVERNMENT DOCUMENTS

The following documents of the exact issue shown form a part of this document to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

√ Air Force Intelligence Support Agency Prototype Specification For ARC Digital Raster Imagery (ADRI), 3rd Draft Edition, August 1991

√ Defense Mapping Agency Product Specifications For Digital Landmass System (DLMS) Data Base, Second Edition, April 1983

Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions should be obtained from the contracting agency or as directed by the contracting officer.

2.2 NON-GOVERNMENT DOCUMENT

Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions should be obtained from the contracting agency or as directed by the contracting officer.

SECTION 3. ADRI EVALUATION METHODOLOGY

The purpose of this ADRI evaluation process is an initial comparison of the accuracies of point positioning data extracted from the ADRI product to control data extracted from high accuracy controlled imagery. This section presents a brief discussion of the ADRI product followed by a discussion of the statistics employed in analysis and their interpretation within this analysis. This section concludes with a discussion of the procedures used to conduct the data generation and analysis.

3.1 ADRI PRODUCT

The ARC Digital Raster Imagery (ADRI) product is designed to provide a general purpose data set of support data and computer readable digital images derived from various sources for Air Force weapon systems, and to serve as the imagery source for the Common Mapping, Charting,

Geopositioning, and Imagery Program (CMP). The ADRI is a standardized product which formats imagery data from various sources such as SPOT and LANDSAT into an image projected in the Equal Arc Second (ARC) raster system. The ARC system is specified in the Prototype Specification For ADRI, 3rd Draft Edition, August 1991.

The ADRI product has an accuracy requirement of ≤ 61 meters for horizontal absolute positioning and a relative (point to point) accuracy of ≤ 61 meters[2.] The goal of the ADRI product, comceptually, is to retain the horizontal accuracy equivalent to the ground sample distance (GSD) of the source imagery. ADRI imagery for this study was SPOT 10m panchromatic imagery, which has a GSD of 10 meters. The ADRI product does not include an explicit vertical accuracy requirement.

3.2 ADRI EVALUATION PROCESS

The ADRI evaluation process consisted of two activities. The first activity was an evaluation of the absolute horizontal and vertical accuracy of the product. The second activity was the evaluation of the relative horizontal and vertical accuracy of the product. Both absolute and relative horizontal evaluation activities employed the same statistical measures for the analysis. The statistical measures employed were the mean error in latitude and longitude, standard deviation (sigma) of the errors in latitude and longitude, the root mean square (RMS) of the errors for latitude and longitude, and the average error for latitude and longitude. The vertical accuracy analysis employed mean height error, standard deviation of the height errors, RMS of the height errors, and average height error.

All statistics were computed with the delta values or difference in latitude, longitude and/or height between a set of control points that were provided by the government and generated from high accuracy controlled imagery, and sets of measured locations of the same point using the ADRI product and the ADRI Evaluation software developed by TRIFID Corp. for Rome Laboratory under this task. A full description of the computation of the evaluation statistics is provided in Appendix A of the ADRI Assessment (ADRIX) Software User's Guide and Reference provided with the evaluation software.

3.2.1 HORIZONTAL ACCURACY ANALYSIS

The processing of the horizontal accuracy begins with the computation of the straight line difference between the known control points and the measured points in both latitude and longitude. The statistical computations are then performed on these differences. The four statistics identified above are then computed for the absolute differences and an absolute 90% Circular Error (90% CE) is computed using the bias and standard deviation.

The mean latitude and longitude error represents the statistical mean of the latitude and longitude differences between the known and measured points. This value is the bias used in the computation of 90% CE. The bias can be thought of as the mean shift that has occurred for all of the measured points. Exhibit 3-1 is a graphic illustration of bias and 90% CE.

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Given the characteristics of the ADRI production methodology and production experience to date, it is expected that a positional bias between the known and measured points would be within a two pixel limit or 20 meters.

The standard deviation is a measure of the distribution of the differences in the measured points. A small standard deviation (or sigma) is indicative of a narrow distribution range with most of the differences clustered near the mean difference. If the sigma for both latitude and longitude differences are the same value, the shape of the ellipse enclosing the points falling within the 90% CE would be round or circular, whereas, a significant difference between the latitude and longitude sigma would form an elliptical shape. The more elliptical the distribution of error, the more bias in one direction is indicated which could result from user sampling error, display biases, or a computation bias in the generation of the product.

Exhibit 3-1
Graphic Illustration of Statistical Bias and the Computation of 90% Circular Error
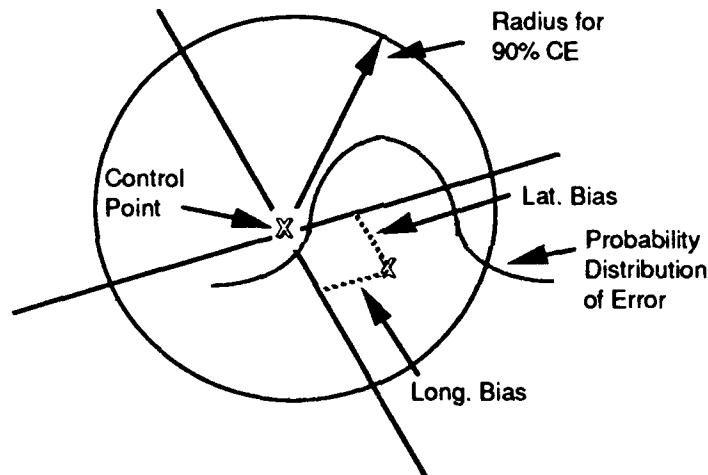
The RMS and average error statistics are statistics which give an indication of the magnitude of the differences. The RMS statistic is the mean of the differences squared, and the average difference is a straightforward average of the absolute value of the differences. The mean error statistic (bias) gives the sampling mean which could be very reasonable. For instance, a zero mean difference could result from data wherein half of the values are different negatively and the other half are different positively, in the same amount. All sample points could be different by ± 5 meters or ±50 meters and yield the same mean error. The RMS and average difference will reflect the magnitude of any sample difference. Both statistical measures should have comparable values, and any significant deviations between these two statistics will indicate a serious sampling error such as measuring the wrong point in the ADRI or using the wrong control points for analysis.

The relative horizontal accuracy analysis is a comparison of the differences between all possible point pairs in the measured points data set. A single delta distance statistic is computed

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r all point pairs the are < 60 kilometers apart, and for a second "bin" of points that are ≥ 60
lometers apart. If there are not enough points in either bin, they are evaluated together as a single
n. For each bin, 90% CE is computed. If there are less than 10 point pairs the sample is too
all to be statistically significant and no relative accuracy statistics are computed.

The relative CE at 90% is computed by ranking the distance differences in order of
agnitude on an ogive. The 90% CE value is determined by where 90% of the ranked point pairs
lls.

2.2 VERTICAL ACCURACY ANALYSIS

The vertical accuracy analysis is performed in much the same manner as the horizontal
alysis. The basic input to the statistical computations is the difference between the height of the
easured points and the control points. Since the source of the height in the measured data set is
igital Terrain Elevation Data (DTED), this analysis is an evaluation of how well the ADRI and
TED products in combination can be used to support point positioning. As stated previously, the
DRI product does not have any explicit vertical accuracy requirements and does not include the
TED.

The elevations for measured points are computed using the companion DTED data. The
orizontal coordinates from the measured points data set are used to interpolate an elevation value
hich is then evaluated against the control elevation that is provided as part of the control data set.

The statistical preparation used in the vertical accuracy analysis compute a mean height
ifference which is the mean of all height differences of all points. This value represents an
levation bias that may exist between the DTED and control data. The standard deviation is
omputed which is a measure of the distribution of the differences about the mean value. The
MS and average absolute difference in height are also computed as measures of the magnitude to
e average difference independent of the sign of the difference. A 90% Linear Error measure
0% LE) is computed using the bias and standard deviation to define the probability distribution
inction over which 90% is computed by integration of that function.

The relative vertical accuracy analysis examines all possible point pairs in the data set and
ivides the point pairs into the same two 'bins' as in the horizontal accuracy analysis (two bins:
60 kilometers apart and ≥ 60 kilometers apart). If the total number of the point pairs is less than
0, then the analysis is not statistically significant and is not performed.

This vertical accuracy analysis is greatly dependent upon the accuracy of the DTED
roduct. The DTED product has an absolute vertical accuracy requirement for Level I DTED of
30 meters. The derived elevations for this analysis use the known points (control) coordinates to
ompute the interpolated elevation which is then evaluated against the control heights provided by
e government. Significant differences in vertical computations are, therefore, indicative of error
the DTED product as opposed to the ADRI product. This analysis is a first step toward
sessing the utility of the combination of these two products within the limitations of the DTED.

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3.3 ADRI EVALUATION DATA SETS

For the ADRI Evaluation task, 15 government-furnished geocells of ADRI data and companion DTED data were provided. The 15 geocells mapped into regions over eastern UK and northern Germany. Exhibit 3-2 shows the location and ADRI data sources used. As illustrated, the ADRI data sources were four Distribution Rectangles (DR) on 8mm digital tapes. Simple logistics with data storage and retrieval software made it easiest to handle the test as four separate areas of interest (AOIs) which correspond to each DR. This enabled the loading of the data to proceed smoothly and eliminated the need to modify the transfer file information or change file names.

On a 1.6 gigabyte hard disk, four subdirectories were created, one for each ADRI DR. Within each subdirectory, one DTED subdirectory was created for the corresponding DR. The names of the four test AOIs were:

√ /adri/tape7 — three geocells in the UK (#s 11,15 & 16 of the DR)
√ /adri/tape9 — three geocells in northern Germany (#s 1, 6 & 11 of the DR)
√ /adri/tape10 — three geocells in northern Germany (#s 7, 13 & 16 of the DR)
√ /adri/tape11 — six geocells in northern Germany (#s 4, 6, 9, 14, 17 & 20 of the DR)

3.3.1 CONTROL POINT GENERATION

Once the four AOIs were loaded on the Synectics SUN IPC system, the ADRI evaluation software was employed to assist in the identification of control points for the analysis. In conjunction with government-provided high accuracy controlled imagery, the program LPM, Mr. James Sieffert and the Synectics analyst, Mr. Michael Wasilenko, viewed each AOI and randomly selected areas over which high accuracy controlled imagery was available. All control point locations were defined to be the center of the intersections of roads which were clearly identifiable on both the ADRI and the high accuracy controlled imagery products. As a general rule, there were five control points taken from each geocell. Exhibits 3-3a through 3-3d show the distribution of the control points within each geocell.

There were some notable limitations in the generation of the control data sets. The most significant limitation occurred with the data from tape9 over northern Germany. In the process of loading the images, only the first geocell would successfully load. Geocells 6 and 11 would not load and examination of the problem indicated a defective 8mm tape. Consequently, the tape9 test data set was limited to one geocell. Subsequently, a valid copy of the tape9 DR was received and could be viewed with the ADRI software. Unfortunately, it was made available too late to identify

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Exhibit 3-2
Location of 15 Geocells Used for ADRI Evaluation
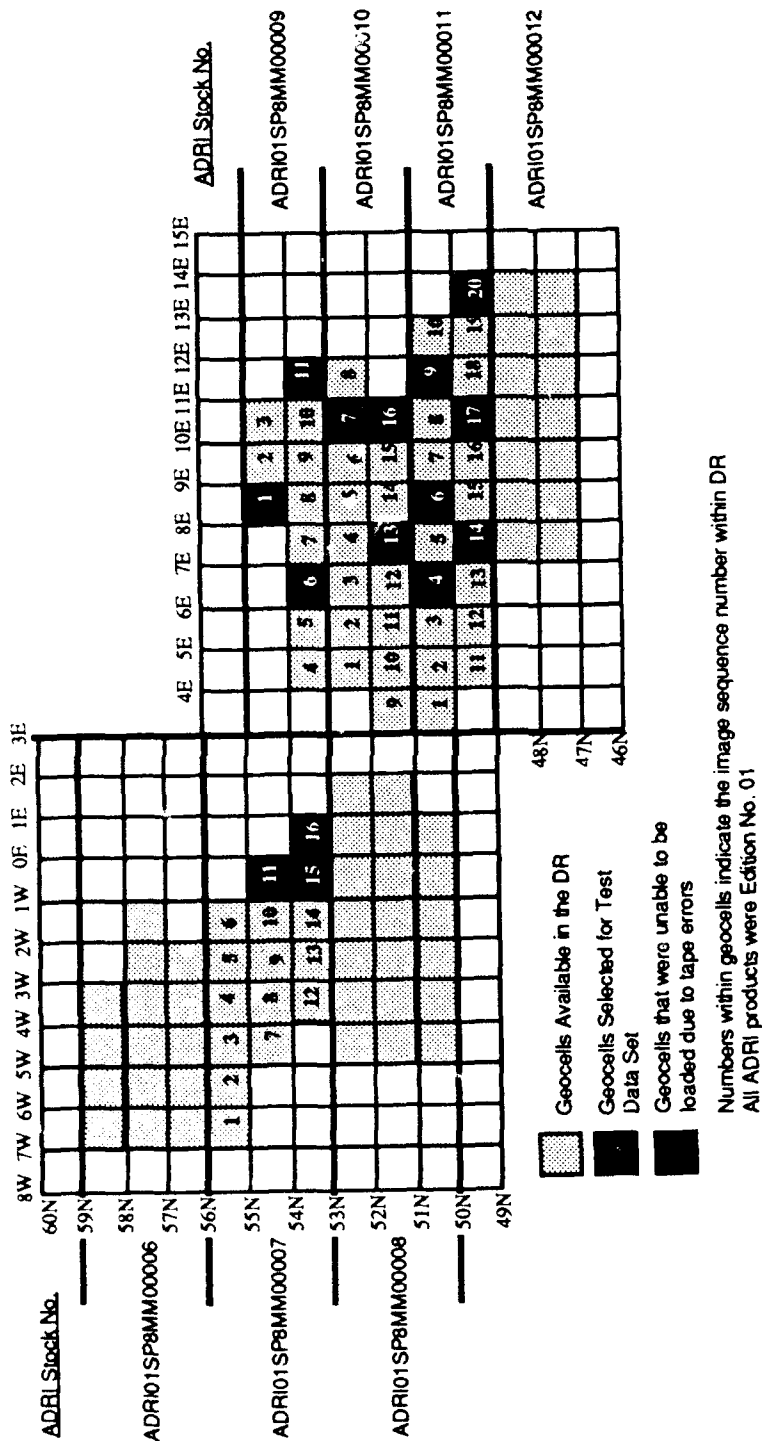
Exhibit 3-3a
Distribution of Control Points in the United Kingdom Area of Interest
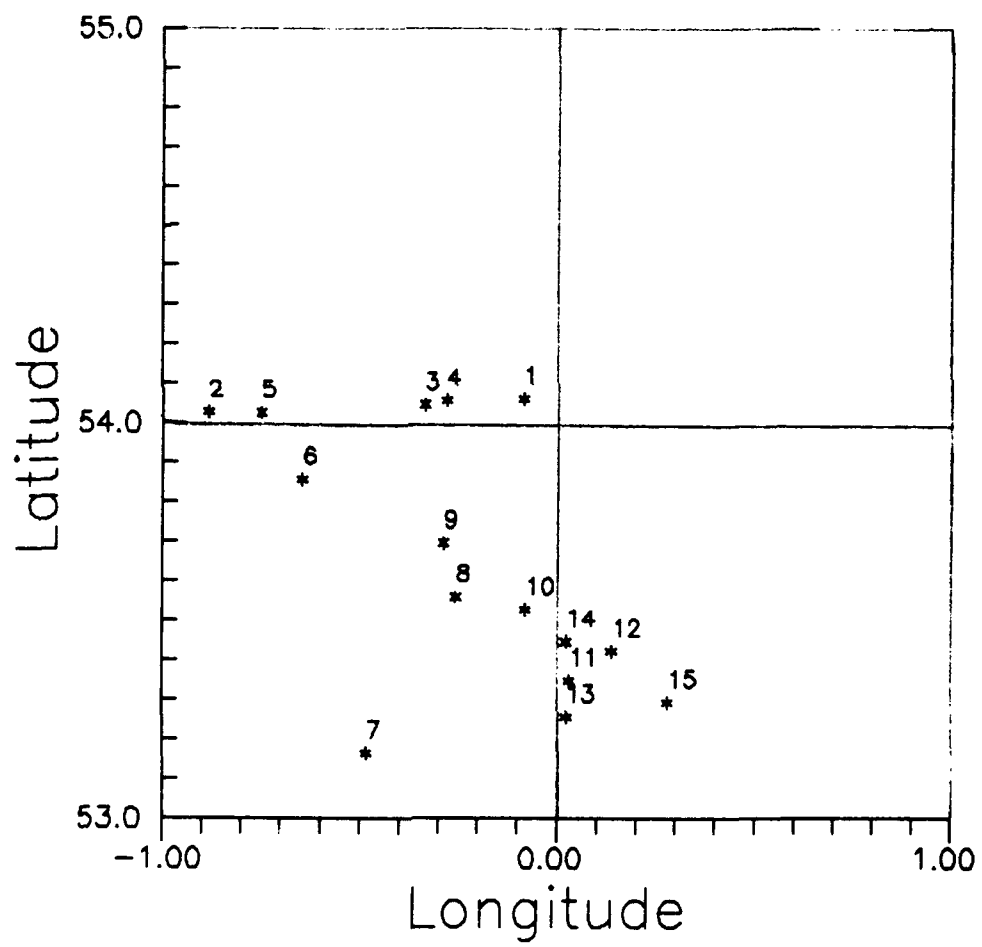
Exhibit 3-3b
Distribution of Control Points in the Germany #1 Area of Interest
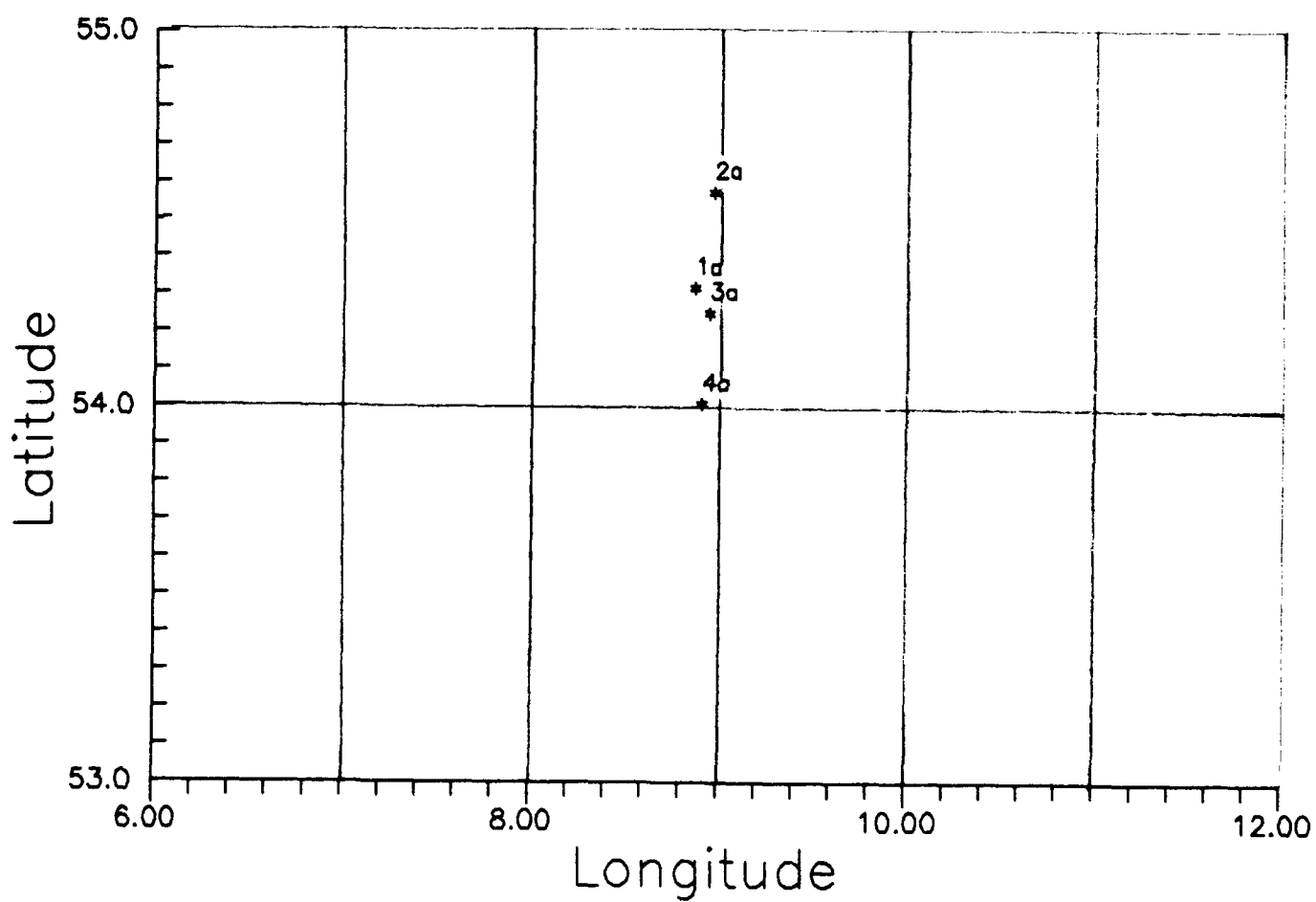
Exhibit 3-3c
Distribution of Control Points in the Germany #2 Area of Interest
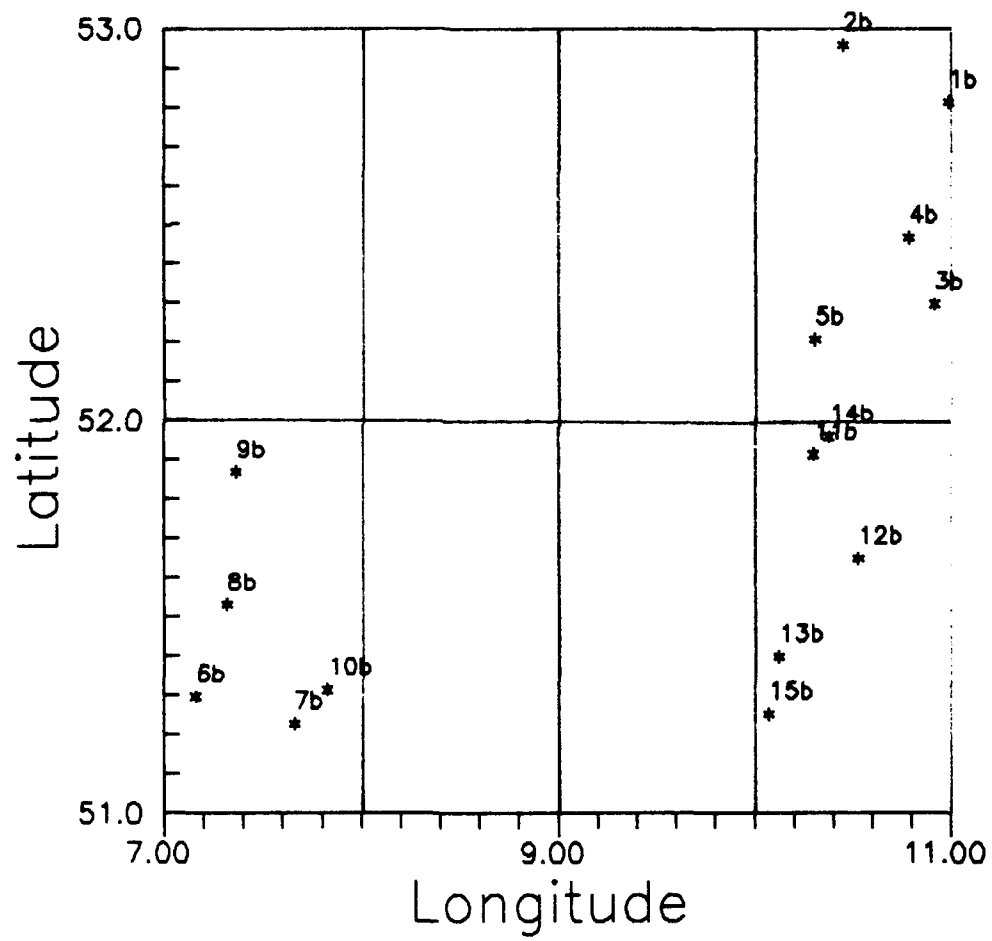
Exhibit 3-3d
Distribution of Control Points in the Germany #3 Area of Interest
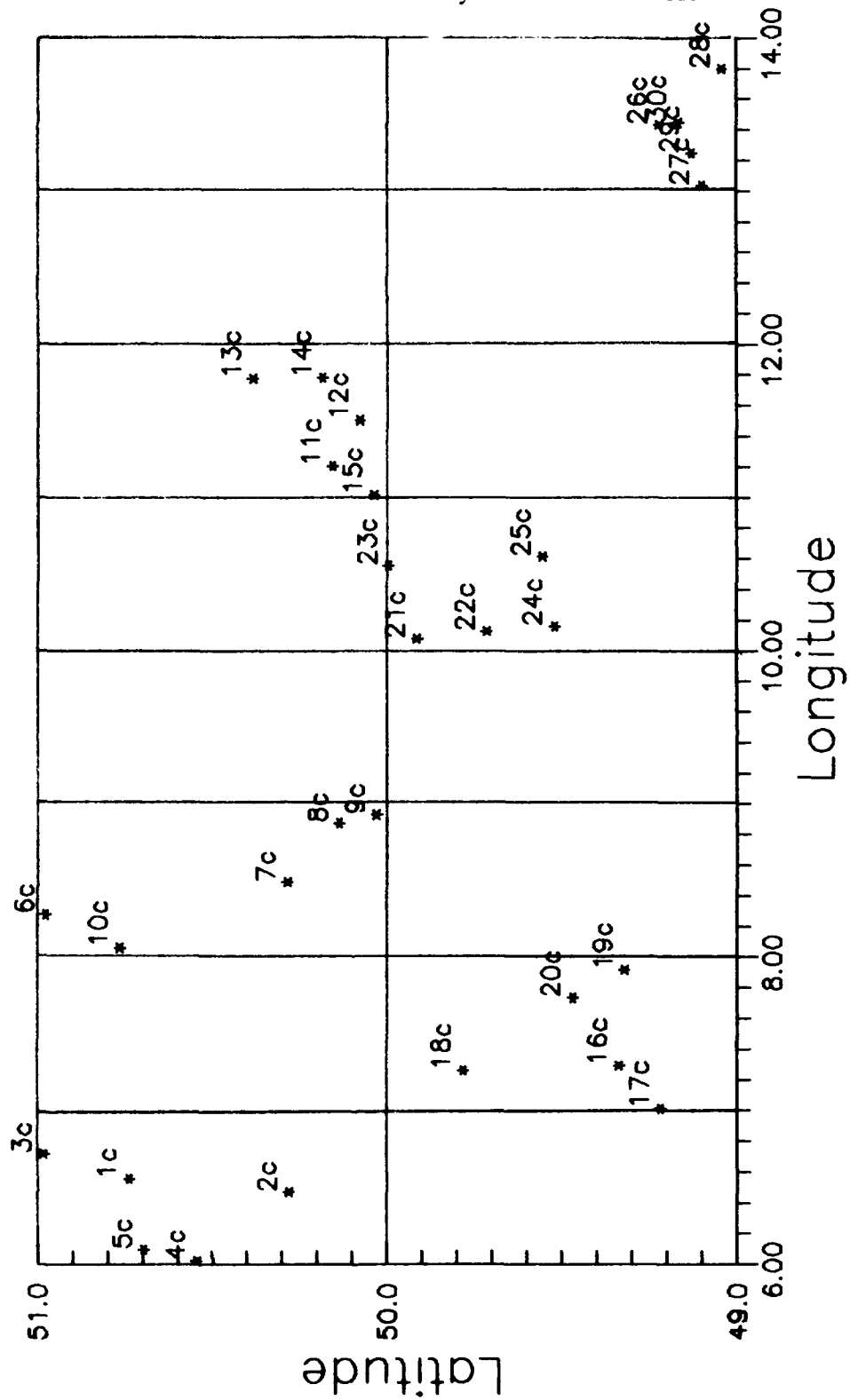
the control. The absence of ADRI imagery also limited the number and distribution of control points over some areas. Both of these limitations combined to restrict the number of control points for the tape9 data set to just four points.

In total, there were 64 control points identified. These points were then extracted from the hardcopy high accuracy controlled imagery. These points are now defined as the test control and are assumed to be error free for purposes of analysis.

3.4 ADRI EVALUATION PROCEDURES

Once the control point data were received from the government, they were entered into the ADRI evaluation directory and saved as the control data sets. The control data were provided in digital and hard copy form as an Excel spreadsheet on a Macintosh. It was then possible, using a Macintosh connected to the SUN IPC via NCSA/BYU Telnet 2.3.1 communication software, to create the control data files directly on the SUN through a cut and paste process which eliminated the potential for any transcription errors that could occur if the data were manually typed into the system. Once the control data were validated on the SUN IPC, four subdirectories were created to contain the control data and all data collected and generated during analysis.

3.4.1 PRELIMINARY SYSTEM EVALUATION

As a validation step for the ADRI evaluation software and verification of the control data sets, a preliminary system evaluation was conducted using the control data points saved during the process of control point identification as the measured points, and the control data transferred from the Macintosh as the known points. This process surfaced some irregularities in the data and some environment problems with the ADRI software and test data.

The first deviation surfaced in the horizontal accuracy analysis. In the AOI over the UK, and in two of the Germany AOIs, the statistics indicated a gross error in the data. Close examination showed that five control points were located at different road intersections than those located in the identification process. This was most likely caused by confusion over which point was being identified on the ADRI and on the hardcopy imagery. Fortunately, the points from the control data sets were also identifiable on the ADRI product and therefore used in the evaluation. A valuable result of this exercise was the validation of the statistics and their interpretation, since it was the analysis of these statistics which surfaced the data discrepancies. In other words, the statistical computations behaved as expected with corrupted inputs.

The second problem that surfaced involved the vertical analysis. The DTED for the test data sets were also provided on 1/4" tape as a single distribution rectangle with 15 geocells of data. The DTED cells were then loaded directly into the appropriate subdirectories for the AOIs. Attempts to execute the vertical accuracy analysis with the preliminary data sets failed. Examination of this problem, including consultation with TRIFID Corp., surfaced the need for the

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DTED files to be numbered sequentially within each subdirectory. When loading the DTED cells for the DR, they were numbered DMADT000 to DMADT014, and the names were not changed. Through the simple process of renaming the files within each subdirectory, the vertical accuracy analysis was found to be working properly.

The third situation which the preliminary evaluation surfaced was the effect of user bias introduced during the sampling procedure. For the UK test data set, sample points were taken at the 1:1(no magnification), 1:2 (1x magnification) and 1:4 (2x magnification) resolutions and a fourth set was taken with a sample point at each of the three resolutions. The results of this analysis showed that the quality of sampling was best at the 1:4 resolution. This was not surprising since at that scale, a feature is still identifiable and a specific pixel can be easily selected repeatedly. The results of this preliminary analysis are illustrated in Exhibit 3-4. As one looks at the behavior of the statistics for each sampling method, one can see that all measures are most accurate at the 1:4 resolution. The apparent precision of the multiple resolution sample can be explained as a side effect of familiarity of the sample points by the user. The results of this preliminary analysis indicated that the sample procedure for the final ADRI evaluation can be done by sampling points at 2x magnification, and each point need only be sampled once since the pixel selected can be easily repeated at that magnification.

Exhibit 3-4
Results of a Preliminary Analysis Evaluating Sampling Methods
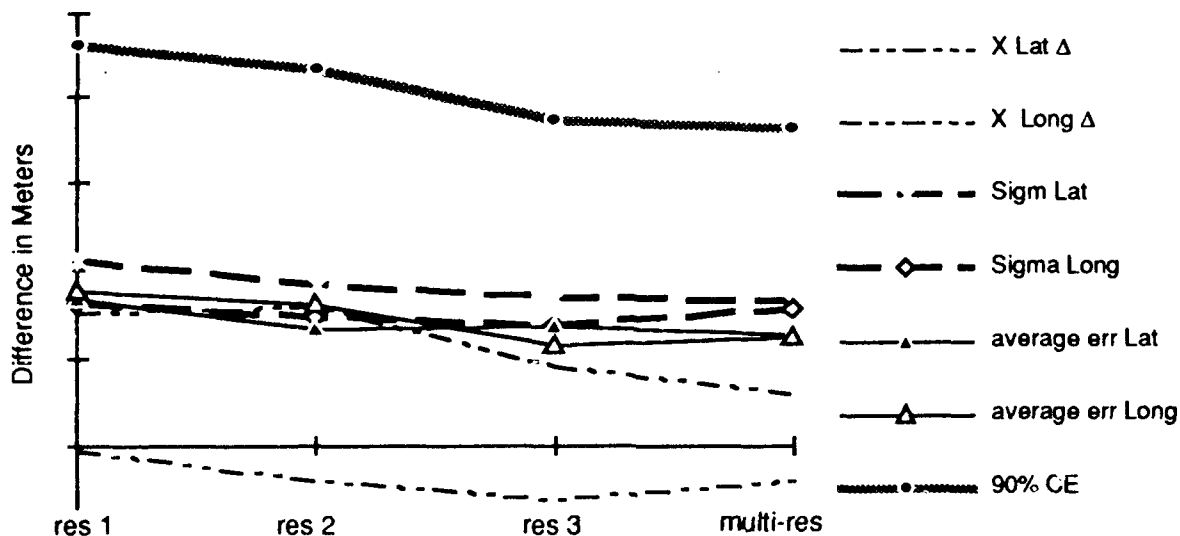
3.4.2 FINAL ADRI EVALUATION PROCEDURE

The final ADRI evaluation procedure was the straightforward process of sampling each control point location for each AOI and then executing the statistical applications. The procedure specification is:

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1)   *Execute the ADRI evaluation software specifying the appropriate AOI.*

2)   Use the ADJUST CONTRAST menu bar item as needed to make the ADRI image as easy to view as possible.

3)   Under the FILE menu bar item select the SET DIRECTORY item and enter the subdirectory where the control data can be found, and where the measured data and statistical files will be saved.

4)   Under the FILE menu bar item set the INPUT VISIT FILE to the control data points file. For this analysis the control file names were: UKtest.pt, ger1test.pt, ger2test.pt, and ger3test.pt.

5)   Under the FILE menu bar item set the OUTPUT POINT FILE to the name of the file to receive the measured points. For this analysis the measure point file names were: UK3res.pt, ger13res.pt, ger23res.pt, and ger33res.pt.

6)   Under the FILE menu bar item set the REPORT NAME to the name for the statistical files that contain the data for horizontal and vertical accuracy analysis. For this analysis the report file names were: UK3rpt, ger13rpt, ger23rpt, and ger33rpt.

7)   Under the VISIT FILE POINT menu bar item select the first control point. The ADRI image will be redrawn with the control located in the center of the image and with a box around the location of the point in both the reference and 1:1 image. N.B. the user should note the proper intersection at this time because the reference box is not shown on the enlargement.

8)   Select the MAGNIFY menu bar item to magnify the image to the 1:2 magnification.

9)   Select the MAGNIFY menu bar item a second consecutive time to reach the 1:4 magnification. At this scale the road intersection should be discernible, but blocky in appearance. Also, there is no reference as to the location of the control point that could bias user point selection.

10)   Place the graphic cursor at the best location indicating the center point of the road intersection and click the left mouse button. A pop up menu should appear offering to set the selected point to that location, or to move the center of the image to that location. Select the "move to that location" option. A box will be drawn around that point. CAUTION: Do not choose the recentering option since this will cause the image to be redrawn at the 1:1 scale and it would be necessary to start the procedure again.

11)   Select the SAVE POINT menu bar item. This selection will offer to tag this point with the same ID as the control point. Choose that option or type in the same identification name as the control point. Entering a different identification name will invalidate the analysis.

12) Repeat the process from step 7 to begin the selection of the next point.

13) Once all the measured points have been sampled and saved select the appropriate analysis application under the ANALYZE menu bar item.

SECTION 4. ADRI EVALUATION RESULTS

The ADRI evaluation procedure presented in the previous section was conducted on each of the four test Areas of Interest (AOIs). The four test areas will be referred to in this section and in the data tables presented as: UK (United Kingdom), Germany #1, Germany #2, and Germany #3. The number of evaluation data points for absolute accuracy analysis and the number of point pairs in each "bin" (low bin < 60 km, high bin ≥ 60 km) for relative accuracy analysis are shown in Exhibit 4-1. As noted in the previous section, one of the test AOIs over northern Germany had difficulty loading all three geocells. That test AOI is the Germany #1 AOI and, as one can see, has only four test points.

Exhibit 4-1
ADRI Evaluation Test Data Set Characteristics

AOI	# Points	# Point Pairs	# Pairs < 60km	# Pairs ≥ 60km
UK	15	105	60	45
Germany #1	4	6	6	0
Germany #2	15	105	25	80
Germany #3	30	435	50	385
Total # for Analysis	64	651	141	510

4.1 HORIZONTAL ACCURACY ANALYSIS

The horizontal accuracy requirement for the ADRI product derived from SPOT 10m panchromatic imagery is ±61 meters. The ADRI product generation also requires the maintenance of the resolution of the source imagery which means that the test imagery for this evaluation also has a 10m resolution. With this resolution, one would expect selection precision to be within two pixels which translates to ±20m if points are distinctive and clearly defined. Consequently, the expected result of this analysis are that the process of point positioning with the ADRI product should fall within a two pixel range and should be sufficiently accurate to support all but the most demanding point positioning requirements.

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Exhibit 4-2 is a compilation of the horizontal accuracy statistics for each of the four test AOIs. The data are statistically comparable for all test areas with the possible exception of the Germany #1 data set. The data for this test area clearly show the most deviation. For instance, the latitude and longitude mean differences of -13.32 and -15.72 meters, respectively, are substantially larger than the other data sets which have a maximum difference of 5.76 meters. However, it is important to note that this deviation falls within the range of two pixels which is not significant. The small size of the data set is the most reasonable explanation for the Germany #1 variations.

<div align="center">

Exhibit 4-2
ADRI Evaluation, Horizontal Accuracy Analysis Statistics

</div>

AOI	X Δ Lat	X Δ Long	sigma Lat	sigma Long	RMS Lat	RMS Long	Av. Error Lat	Av. Error Long	90% CE	Rel CE <60km	Rel CE ≥60km
UK	-3.08	4.46	8.39	6.86	8.67	7.99	6.83	5.77	18.55	24.45	21.29
Germany #1	-13.32	-15.72	3.38	3.16	13.64	15.96	13.32	15.72	25.32	insufficient data	insufficient data
Germany #2	-3.10	1.90	7.06	7.05	7.49	7.07	5.96	5.48	16.20	12.07	17.52
Germany #3	-2.66	5.76	6.42	8.44	6.85	10.10	5.53	8.25	18.73	17.95	20.00
Mean of 64	-5.54	-0.90	6.31	6.38	9.16	10.28	7.91	8.81	19.70	N/A	N/A
Mean of 60	-2.95	4.04	7.29	7.45	7.67	8.39	6.11	6.50	17.83	18.16	19.60

The summary statistics at the bottom of the table show the overall values for each statistic by treating the 64 points as a single data set. The last row in the table shows the summary statistics with the four points from the statistically insignificant Germany #1 data set eliminated. The statistics do improve when looking at the 60 point sample, but it is important to note that all values are indicative of acceptable accuracies. As one can see, the accuracy of the ADRI product falls well within expected parameters and has accuracies which clearly fall within the two pixel limit for absolute accuracies. The bias, or latitude and longitude offset, in all but the Germany #1 area, is within the target pixel ranging from 1.90 to 5.76 meters, which is physically as accurate as the selection could be, given the resolution of the imagery.

The standard deviations (sigma values) all indicate an acceptable error distribution. The data indicates that the sampling procedure did not introduce any bias in either the latitudinal or longitudinal direction with a slightly larger latitudinal difference with the UK data set (sigma lat. = 8.39; sigma long = 6.86) and a slightly larger longitudinal difference in the Germany #3 data set (sigma lat. = 6.42; sigma long = 8.44). Both the Germany #1 and #2 data sets have equivalent latitudinal and longitudinal distribution of differences. The small size of the Germany #1 data set is the reason for the relatively large distance errors with a relatively small sigma which means a very steep distribution. With a data set this small, one large difference can influence the entire sample, which is what happened in this case.

The bias and standard deviation are the statistics used to compute the 90% Circular Error (CE). The 90% CE values for the data sets as presented in Exhibit 4-2, are the radii of a circle in meters about each control point that would encompass 90% of the measured points. For the three most significant data sets, the 90% CE falls within the two pixel limit and indicates acceptable

accuracies. The Germany #1 data set is greater than the 2 pixel limit but is too small a sample to be considered statistically significant.

The RMS and average error statistics measure the magnitude of the differences about the mean. In each case, the values are consistent with the analysis based on the mean and standard deviation. The RMS values are larger than the mean values which indicate that the distribution of differences are both positive and negative. This conclusion is also supported by the balanced standard deviation for latitude and longitude differences. The average error statistics further support the same analysis as the value of the absolute differences which show a balanced distribution as well as acceptable accuracies.

The relative horizontal accuracy analysis is limited to the 90% CE error for two data bins. The low data bin consists of all the point pairs that are < 60 km apart and the high bin consists of point pairs that are ≥ 60 km apart. This statistic gives a measure of the spatial distribution of error over the ADRI product. A consistently significant difference (i.e., 30 to 40 meters) between the 90% CE of the two data bins would indicate a systematic error being distributed throughout the product which would be greatest over longer distances.

The findings of this initial analysis show that there is no indication of any systematic errors over the area of coverage of the ADRI product. The 90% CE for the relative horizontal accuracies of both the low and high bins are statistically comparable and within acceptable accuracies. The 90% CE values range from 12.07 for the low bin in the Germany #2 data set to 24.45 in the low bin for the UK data set. The average 90% CE for all data pairs (except the 6 pairs for the Germany #1 data set) falls within the 2 pixel limit, which means that one can expect a consistent level accuracy for point positioning anywhere within an ADRI image. The Germany #1 data set had less than 10 data pairs and was therefore eliminated from the relative accuracy analysis as being too small to be statistically significant.

4.2 VERTICAL ACCURACY ANALYSIS

The vertical accuracy evaluation portion of this analysis is an examination of the utility of the Digital Terrain Elevation Data (DTED) Level I product in conjunction with the ADRI product. The results of this evaluation are indicative of the quality of the DTED Level I product and do not reflect on the ADRI product. Measured elevation values are interpolated from the DTED Level I data using the latitude and longitude values in the control data sets. Measure points from the ADRI product are not used in this analysis.

The expected results of this evaluation are that the elevation data will have at least the same accuracy levels as required for the product, which is ± 30 meters. The statistics for the absolute and relative accuracy analysis are presented in Exhibit 4-3. The same data sets and control points were used for the vertical accuracy analysis as were used for the horizontal accuracy analysis.

Exhibit 4-3
ADRI Evaluation, Vertical Accuracy Analysis Statistics

	Mean	Sigma	RMS	Average Err	90% LE	Low Bin 90% LE	High Bin 90% LE
U K	-1.47	14.48	14.06	11.39	23.94	32.49	39.66
Germany #1	-33.59	0.70	33.59	33.59	34.48		
Germany #2	-30.84	15.59	34.32	31.55	50.83	45.35	39.07
Germany #3	-44.06	18.97	47.84	44.06	68.37	31.15	45.58
Average	-27.49	12.44	32.45	30.15	44.41	36.33	41.44

As one can see in Exhibit 4-3, the accuracy level of the DTED Level I data falls short of the expected accuracy results. The UK data set did seem to perform the best with a mean elevation difference, standard deviation (sigma), RMS, average error and 90% LE within the ±30 meter requirement. The most likely explanation for the rather large values is the relative effect of local relief, illustrated in Exhibit 4-4, on the quality of the DTED and the interpolation process. The UK data set was over an area that has a relatively small local relief, which may have contributed to better performance of the data. The UK local relief is approximately 216 meters, but this is due almost entirely to control #5 which contributes to the majority of the relief. The data set over northern Germany has a local relief distribution as also shown in Exhibit 4-4. The four point data set for Germany #1 was insignificant for this analysis, while the other two Germany data sets show rather significant elevation variations, which is indicative of a much more variable terrain and would cause errors in the DTED product as well as in the interpolation of elevations from the product.

Exhibit 4-4
ADRI Evaluation, Control Local Relief Characteristics

ADRI Evaluation Control Points Local Relief

19
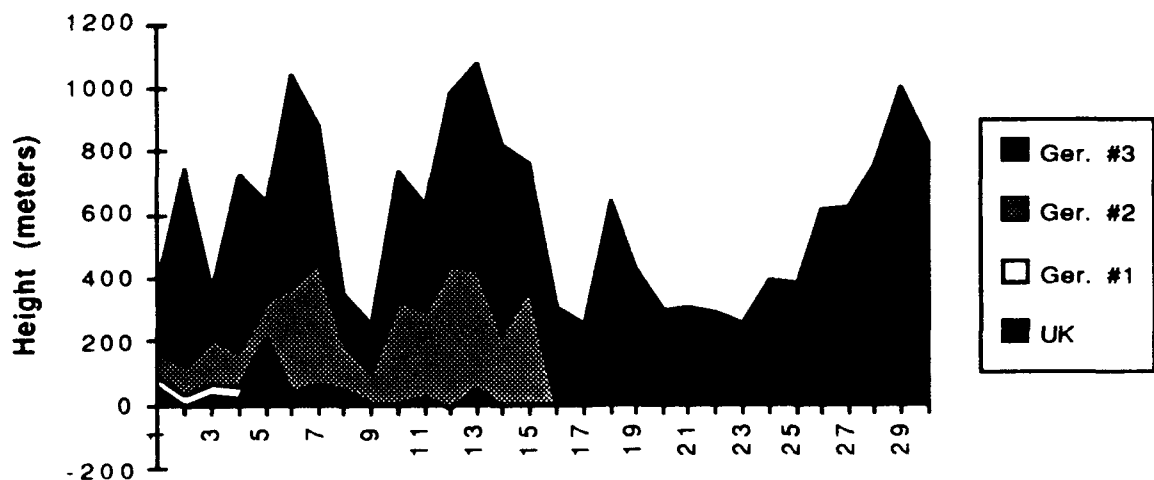
The findings of this analysis are that the DTED Level I product is basically inadequate for all but the most general requirements for point positioning and is probably not the most advantageous companion for the ADRI.

4.3 SUMMARY

The findings of this initial analysis of the ADRI product are that, in terms of horizontal accuracy, the ADRI product performs well within its required limits for accuracy and can be expected to support horizontal point positioning requirements to within 20 meters of ground truth. The companion DTED data are, however, inadequate as an elevation data source with accuracies that can be expected to 2.5 to 3.5 times less accurate than the horizontal positioning.

This is an initial study, and a relatively small sample of points was used. Other factors such as variations in the display quality, user familiarity, cursor design, user interface, and image sources were held constant throughout this analysis and should be examined as a means of improving the point positioning process. The vertical accuracy problem requires more analysis with the possible use of Level II DTED which is at a comparable resolution with the ADRI product. Finally, more geographic areas should be examined so that a broad cross-section of terrain and cultural phenomena are part of the evaluation. This would support the broad applicability of the ADRI product.

APPENDIX A

STATISTICS SUMMARY, UK TAPE ADRI01SP8MM00007 HORIZONTAL ANALYSIS
ALL VALUES IN METERS

ABSOLUTE HORIZONTAL ACCURACY

POINT ID	DELTA LAT	DELTA LON
uk1	-5.14	17.42
uk2	-16.85	15.53
uk3	-9.73	9.26
uk4	-8.15	12.20
uk5	-8.14	2.89
uk6	3.13	1.28
uk7	1.58	2.14
uk8	-7.07	-6.71
uk9	20.32	0.32
uk10	-3.21	3.81
uk11	0.92	-0.30
uk12	-6.16	1.65
uk13	-7.38	-2.78
uk14	-2.49	9.65
uk15	2.15	0.58

TOTAL NUMBER OF POINTS = 15

90% CIRCULAR ERROR = 18.55

	LAT	LONG
MEAN	-3.08	4.46
SIGMA	8.39	6.86
RMS	8.67	7.99
AVERAGE ERROR	6.83	5.77

HORIZONTAL RELATIVE ACCURACY
TOTAL NUMBER OF POINT PAIR COMBINATIONS = 105

LOW BIN: ALL POINTS LESS THAN 60 KM APART

ID POINT COMBINATION		DELTA DISTANCE
uk1	uk2	10.53
uk1	uk3	7.88
uk1	uk4	5.14
uk1	uk5	10.53
uk1	uk6	15.10
uk1	uk9	30.35
uk2	uk3	5.69
uk2	uk4	2.45
uk2	uk5	12.70
uk2	uk6	24.45
uk2	uk9	36.45

```
uk3  uk4         3.27
uk3  uk5         6.28
uk3  uk6         3.70
uk3  uk8         4.18
uk3  uk9        30.68
uk4  uk5         9.31
uk4  uk6         0.39
uk4  uk8         1.61
uk4  uk9        28.32
uk5  uk6        11.15
uk5  uk9        23.56
uk6  uk8         3.19
uk6  uk9        11.16
uk6  uk10        6.21
uk7  uk8        11.09
uk7  uk10        3.05
uk7  uk11        2.44
uk7  uk12        4.81
uk7  uk13        7.32
uk7  uk14        2.77
uk7  uk15        1.36
uk8  uk9        26.19
uk8  uk10        8.98
uk8  uk11        2.13
uk8  uk12        6.81
uk8  uk13        2.19
uk8  uk14       11.03
uk8  uk15        0.21
uk9  uk10       21.03
uk9  uk11       16.70
uk9  uk12       20.25
uk9  uk13       24.35
uk9  uk14       23.80
uk9  uk15       13.98
uk10 uk11        5.30
uk10 uk12        0.16
uk10 uk13        2.63
uk10 uk14        2.97
uk10 uk15        6.12
uk11 uk12        4.05
uk11 uk13        8.43
uk11 uk14        3.90
uk11 uk15        0.40
uk12 uk13        2.83
uk12 uk14        6.32
uk12 uk15        7.51
uk13 uk14        4.90
uk13 uk15        5.58
uk14 uk15        9.71
```

RELATIVE CE 90% = 24.45

HIGH BIN: ALL POINTS GREATER THAN 60 KM APART

ID POINT COMBINATION	DELTA DISTANCE
uk1 uk7	10.03
uk1 uk8	11.98
uk1 uk10	10.22
uk1 uk11	15.23
uk1 uk12	9.78
uk1 uk13	8.81
uk1 uk14	7.04
uk1 uk15	16.46
uk2 uk7	21.29
uk2 uk8	21.32
uk2 uk10	17.85
uk2 uk11	23.62
uk2 uk12	17.21
uk2 uk13	18.05
uk2 uk14	14.48
uk2 uk15	23.90
uk3 uk7	10.55
uk3 uk10	7.79
uk3 uk11	12.99
uk3 uk12	6.36
uk3 uk13	5.35
uk3 uk14	6.73
uk3 uk15	14.45
uk4 uk7	8.30
uk4 uk10	6.64
uk4 uk11	11.89
uk4 uk12	5.66
uk4 uk13	3.97
uk4 uk14	6.17
uk4 uk15	14.04
uk5 uk7	9.70
uk5 uk8	5.92
uk5 uk10	3.29
uk5 uk11	9.24
uk5 uk12	2.27
uk5 uk13	3.46
uk5 uk14	0.30
uk5 uk15	9.34
uk6 uk7	1.66
uk6 uk11	0.74
uk6 uk12	6.58
uk6 uk13	6.56
uk6 uk14	9.77
uk6 uk15	0.18
uk7 uk9	17.91

RELATIVE CE 90% = 21.29

STATISTICS SUMMARY, UK TAPE ADRI01SP8MM00007 VERTICAL ANALYSIS
ALL VALUES IN METERS

ABSOLUTE VERTICAL ACCURACY

POINT ID	DELTA HEIGHT
uk1	20.26
uk2	24.51
uk3	-8.61
uk4	-14.24
uk5	-24.82
uk6	4.59
uk7	-19.40
uk8	-19.79
uk9	-1.12
uk10	6.50
uk11	0.22
uk12	12.70
uk13	-3.46
uk14	5.60
uk15	-4.98

NUMBER OF POINTS = 15

90% LINEAR ERROR =	23.94
MEAN	-1.47
SIGMA	14.48
RMS	14.06
AVERAGE ERROR	11.39

VERTICAL RELATIVE ACCURACY
TOTAL NUMBER OF POINT PAIR COMBINATIONS = 105

LOW BIN: ALL POINTS LESS THAN 60 KM APART

ID POINT COMBINATION	DELTA HEIGHT
uk1 uk2	4.25
uk1 uk3	28.87
uk1 uk4	34.50
uk1 uk5	45.08
uk1 uk6	15.68
uk1 uk9	21.38
uk2 uk3	33.12
uk2 uk4	38.75
uk2 uk5	49.33
uk2 uk6	19.93
uk2 uk9	25.63
uk3 uk4	5.63
uk3 uk5	16.21
uk3 uk6	13.19
uk3 uk8	11.18
uk3 uk9	7.49
uk4 uk5	10.58

```
          uk4  uk6        18.83
          uk4  uk8         5.55
          uk4  uk9        13.12
          uk5  uk6        29.40
          uk5  uk9        23.70
          uk6  uk8        24.38
          uk6  uk9         5.71
          uk6  uk10        1.91
          uk7  uk8         0.39
          uk7  uk10       25.90
          uk7  uk11       19.62
          uk7  uk12       32.10
          uk7  uk13       15.94
          uk7  uk14       25.00
          uk7  uk15       14.41
          uk8  uk9        18.67
          uk8  uk10       26.29
          uk8  uk11       20.01
          uk8  uk12       32.49
          uk8  uk13       16.33
          uk8  uk14       25.39
          uk8  uk15       14.80
          uk9  uk10        7.62
          uk9  uk11        1.34
          uk9  uk12       13.82
          uk9  uk13        2.34
          uk9  uk14        6.72
          uk9  uk15        3.86
         uk10  uk11        6.28
         uk10  uk12        6.20
         uk10  uk13        9.96
         uk10  uk14        0.90
         uk10  uk15       11.48
         uk11  uk12       12.48
         uk11  uk13        3.68
         uk11  uk14        5.38
         uk11  uk15        5.20
         uk12  uk13       16.16
         uk12  uk14        7.10
         uk12  uk15       17.68
         uk13  uk14        9.06
         uk13  uk15        1.53
         uk14  uk15       10.58
```

RELATIVE LE 90% = 32.49

HIGH BIN: ALL POINTS GREATER THAN 60 KM APART

```
   ID POINT COMBINATION        DELTA HEIGHT
              uk1  uk7        39.66
              uk1  uk8        40.05
              uk1  uk10       13.76
              uk1  uk11       20.05
              uk1  uk12        7.56
```

```
uk1 uk13        23.72
uk1 uk14        14.66
uk1 uk15        25.25
 uk2 uk7        43.91
 uk2 uk8        44.30
uk2 uk10        18.01
uk2 uk11        24.30
uk2 uk12        11.81
uk2 uk13        27.97
uk2 uk14        18.91
uk2 uk15        29.50
 uk3 uk7        10.79
uk3 uk10        15.11
uk3 uk11         8.82
uk3 uk12        21.31
uk3 uk13         5.15
uk3 uk14        14.21
uk3 uk15         3.62
 uk4 uk7         5.16
uk4 uk10        20.74
uk4 uk11        14.46
uk4 uk12        26.94
uk4 uk13        10.78
uk4 uk14        19.84
uk4 uk15         9.25
 uk5 uk7         5.42
 uk5 uk8         5.03
uk5 uk10        31.32
uk5 uk11        25.03
uk5 uk12        37.52
uk5 uk13        21.36
uk5 uk14        30.42
uk5 uk15        19.83
 uk6 uk7        23.99
uk6 uk11         4.37
uk6 uk12         8.11
uk6 uk13         8.05
uk6 uk14         1.01
uk6 uk15         9.57
 uk7 uk9        18.28
```

RELATIVE LE 90% = 39.66

STATISTICS SUMMARY, TAPE ADRI01SP8MM00009 HORIZONTAL ANALYSIS
ALL VALUES IN METERS

ABSOLUTE HORIZONTAL ACCURACY

POINT ID	DELTA LAT	DELTA LON
ger3a	-15.94	-16.74
ger1a	-9.59	-13.96
ger2a	-16.42	-19.66
ger4a	-11.33	-12.53

TOTAL NUMBER OF POINTS = 4

90% CIRCULAR ERROR = 25.32

	LAT	LONG
MEAN	-13.32	-15.72
SIGMA	3.38	3.16
RMS	13.64	15.96
AVERAGE ERROR	13.32	15.72

HORIZONTAL RELATIVE ACCURACY
TOTAL NUMBER OF POINT PAIR COMBINATIONS = 6

ALL DATA IS GROUPED INTO A SINGLE BIN

ID POINT COMBINATION	DELTA DISTANCE
ger3a ger1a	3.62
ger3a ger2a	0.60
ger3a ger4a	4.97
ger1a ger2a	7.97
ger1a ger4a	1.86
ger2a ger4a	5.52

INSUFFICIENT DATA TO COMPUTE 90% CE

A-7

STATISTICS SUMMARY, TAPE ADRI01SP8MM00009 VERTICAL ANALYSIS
ALL VALUES IN METERS

ABSOLUTE VERTICAL ACCURACY

POINT ID   DELTA HEIGHT

    ger1a   -32.85
    ger2a   -33.90
    ger3a   -34.40
    ger4a   -33.20

NUMBER OF POINTS = 4

  90% LINEAR ERROR =   34.48
    MEAN   -33.59
    SIGMA   0.70
    RMS   33.59
AVERAGE ERROR   33.59

VERTICAL RELATIVE ACCURACY
TOTAL NUMBER OF POINT PAIR COMBINATIONS = 6

ALL DATA IS GROUPED INTO A SINGLE BIN

ID POINT COMBINATION   DELTA HEIGHT
    ger1a ger2a   1.05
    ger1a ger3a   1.55
    ger1a ger4a   0.35
    ger2a ger3a   0.50
    ger2a ger4a   0.70
    ger3a ger4a   1.20

INSUFFICIENT DATA TO COMPUTE 90% LE

STATISTICS SUMMARY, TAPE ADRI01SP8MM00010 HORIZONTAL ANALYSIS
ALL VALUES IN METERS

ABSOLUTE HORIZONTAL ACCURACY

POINT ID	DELTA LAT	DELTA LON
ger1b	-7.58	-2.13
ger2b	-4.20	-8.33
ger3b	-14.58	4.77
ger4b	-2.92	1.66
ger5b	-4.68	2.01
ger11b	-8.97	1.08
ger12b	-0.23	2.26
ger13b	-3.52	16.24
ger14b	-14.66	-5.32
ger15b	3.10	15.37
ger7b	-2.10	-4.52
ger6b	12.59	4.77
ger8b	-2.13	3.35
ger9b	5.72	3.86
ger10b	-2.41	-6.56

TOTAL NUMBER OF POINTS = 15

90% CIRCULAR ERROR = 16.20

	LAT	LONG
MEAN	-3.10	1.90
SIGMA	7.06	7.05
RMS	7.49	7.07
AVERAGE ERROR	5.96	5.48

HORIZONTAL RELATIVE ACCURACY
TOTAL NUMBER OF POINT PAIR COMBINATIONS = 105

LOW BIN: ALL POINTS LESS THAN 60 KM APART

ID POINT COMBINATION		DELTA DISTANCE
ger1b	ger2b	7.12
ger1b	ger3b	6.39
ger1b	ger4b	5.64
ger2b	ger4b	2.61
ger3b	ger4b	11.90
ger3b	ger5b	0.51
ger3b	ger11b	1.32
ger3b	ger14b	7.16
ger4b	ger5b	0.92
ger5b	ger11b	4.30
ger5b	ger14b	8.57
ger11b	ger12b	7.15
ger11b	ger13b	8.41
ger11b	ger14b	8.55
ger12b	ger13b	7.53

```
            ger12b ger14b              11.58
            ger12b ger15b              10.26
            ger13b ger15b               6.28
             ger7b ger6b                5.98
             ger7b ger8b                4.58
            ger7b ger10b                1.78
             ger6b ger8b               14.10
            ger6b ger10b               12.07
             ger8b ger9b                7.86
            ger8b ger10b                7.98


        RELATIVE CE 90% = 12.07

HIGH BIN:  ALL POINTS GREATER THAN 60 KM APART

    ID POINT COMBINATION       DELTA DISTANCE
             ger1b ger5b                4.68
            ger1b ger11b                0.05
            ger1b ger12b                8.14
            ger1b ger13b                9.97
            ger1b ger14b                7.74
            ger1b ger15b               15.72
             ger1b ger7b                1.34
             ger1b ger6b               16.34
             ger1b ger8b                7.06
             ger1b ger9b               10.34
            ger1b ger10b                0.41
             ger2b ger3b               14.63
             ger2b ger5b                0.73
            ger2b ger11b                3.93
            ger2b ger12b                3.61
            ger2b ger13b                3.70
            ger2b ger14b               10.30
            ger2b ger15b               10.33
             ger2b ger7b                4.16
             ger2b ger6b               20.53
             ger2b ger8b               10.34
             ger2b ger9b               15.30
            ger2b ger10b                2.58
            ger3b ger12b               12.58
            ger3b ger13b               14.96
            ger3b ger15b               20.32
             ger3b ger7b                2.78
             ger3b ger6b               10.03
             ger3b ger8b                2.00
             ger3b ger9b                2.28
            ger3b ger10b                4.86
            ger4b ger11b                5.62
            ger4b ger12b                2.74
            ger4b ger13b                4.46
            ger4b ger14b               13.59
            ger4b ger15b               10.16
             ger4b ger7b                4.75
             ger4b ger6b                9.75
```

```
ger4b  ger8b          1.67
ger4b  ger9b          4.30
ger4b  ger10b         6.62
ger5b  ger12b         4.26
ger5b  ger13b         3.05
ger5b  ger15b         9.62
ger5b  ger7b          4.33
ger5b  ger6b          9.58
ger5b  ger8b          1.92
ger5b  ger9b          3.52
ger5b  ger10b         6.28
ger11b ger15b        14.73
ger11b ger7b          2.73
ger11b ger6b          9.62
ger11b ger8b          3.23
ger11b ger9b          2.78
ger11b ger10b         4.92
ger12b ger7b          7.00
ger12b ger6b          4.56
ger12b ger8b          0.95
ger12b ger9b          0.94
ger12b ger10b         9.03
ger13b ger14b        16.57
ger13b ger7b         20.58
ger13b ger6b         10.70
ger13b ger8b         13.09
ger13b ger9b         14.47
ger13b ger10b        22.80
ger14b ger15b        22.39
ger14b ger7b          5.31
ger14b ger6b         17.52
ger14b ger8b         10.59
ger14b ger9b          9.56
ger14b ger10b         3.11
ger15b ger7b         19.89
ger15b ger6b         10.70
ger15b ger8b         10.91
ger15b ger9b         11.56
ger15b ger10b        21.59
ger7b  ger9b          5.18
ger6b  ger9b          6.90
ger9b  ger10b         2.48
```

RELATIVE CE 90% = 17.52

STATISTICS SUMMARY, TAPE ADRI01SP8MM00010 VERTICAL ANALYSIS
ALL VALUES IN METERS

ABSOLUTE VERTICAL ACCURACY

POINT ID	DELTA HEIGHT
ger1b	-35.40
ger2b	-41.83
ger3b	-33.75
ger4b	-34.70
ger5b	-27.44
ger6b	-66.75
ger7b	-14.09
ger8b	-37.75
ger9b	-33.40
ger10b	-22.00
ger11b	-20.05
ger12b	5.32
ger13b	-40.02
ger14b	-33.05
ger15b	-27.73

NUMBER OF POINTS = 15

90% LINEAR ERROR =	50.83
MEAN	-30.84
SIGMA	15.59
RMS	34.32
AVERAGE ERROR	31.55

VERTICAL RELATIVE ACCURACY
TOTAL NUMBER OF POINT PAIR COMBINATIONS = 105

LOW BIN: ALL POINTS LESS THAN 60 KM APART

ID POINT COMBINATION	DELTA HEIGHT
ger1b ger2b	6.43
ger1b ger3b	1.65
ger1b ger4b	0.70
ger2b ger4b	7.13
ger3b ger4b	0.95
ger3b ger5b	6.31
ger3b ger11b	13.70
ger3b ger14b	0.70
ger4b ger5b	7.26
ger5b ger11b	7.39
ger5b ger14b	5.61
ger6b ger7b	52.66
ger6b ger8b	29.00
ger6b ger10b	44.75
ger7b ger8b	23.67
ger7b ger10b	7.91
ger8b ger9b	4.35

```
          ger8b ger10b          15.76
          ger11b ger12b         25.37
          ger11b ger13b         19.97
          ger11b ger14b         13.00
          ger12b ger13b         45.35
          ger12b ger14b         38.37
          ger12b ger15b         33.06
          ger13b ger15b         12.29
```

RELATIVE LE 90% = 45.35

HIGH BIN: ALL POINTS GREATER THAN 60 KM APART

```
ID POINT COMBINATION          DELTA HEIGHT
          ger1b ger5b           7.96
          ger1b ger6b          31.35
          ger1b ger7b          21.31
          ger1b ger8b           2.35
          ger1b ger9b           2.00
         ger1b ger10b          13.40
         ger1b ger11b          15.35
         ger1b ger12b          40.72
         ger1b ger13b           4.62
         ger1b ger14b           2.35
         ger1b ger15b           7.67
          ger2b ger3b           8.08
          ger2b ger5b          14.38
          ger2b ger6b          24.93
          ger2b ger7b          27.74
          ger2b ger8b           4.07
          ger2b ger9b           8.43
         ger2b ger10b          19.83
         ger2b ger11b          21.78
         ger2b ger12b          47.15
         ger2b ger13b           1.80
         ger2b ger14b           8.78
         ger2b ger15b          14.09
          ger3b ger6b          33.00
          ger3b ger7b          19.66
          ger3b ger8b           4.00
          ger3b ger9b           0.35
         ger3b ger10b          11.75
         ger3b ger12b          39.07
         ger3b ger13b           6.27
         ger3b ger15b           6.02
          ger4b ger6b          32.05
          ger4b ger7b          20.61
          ger4b ger8b           3.06
          ger4b ger9b           1.30
         ger4b ger10b          12.70
         ger4b ger11b          14.65
         ger4b ger12b          40.02
         ger4b ger13b           5.32
         ger4b ger14b           1.65
```

```
ger4b  ger15b          6.97
 ger5b  ger6b          39.31
 ger5b  ger7b          13.35
 ger5b  ger8b          10.31
 ger5b  ger9b           5.96
ger5b  ger10b           5.44
ger5b  ger12b          32.76
ger5b  ger13b          12.58
ger5b  ger15b           0.29
 ger6b  ger9b          33.35
ger6b  ger11b          46.70
ger6b  ger12b          72.07
ger6b  ger13b          26.73
ger6b  ger14b          33.70
ger6b  ger15b          39.02
 ger7b  ger9b          19.31
ger7b  ger11b           5.96
ger7b  ger12b          19.41
ger7b  ger13b          25.94
ger7b  ger14b          18.96
ger7b  ger15b          13.65
ger8b  ger11b          17.71
ger8b  ger12b          43.08
ger8b  ger13b           2.27
ger8b  ger14b           4.71
ger8b  ger15b          10.02
ger9b  ger10b          11.40
ger9b  ger11b          13.35
ger9b  ger12b          38.72
ger9b  ger13b           6.62
ger9b  ger14b           0.35
ger9b  ger15b           5.67
ger10b  ger11b          1.95
ger10b  ger12b         27.32
ger10b  ger13b         18.02
ger10b  ger14b         11.05
ger10b  ger15b          5.73
ger11b  ger15b          7.68
ger13b  ger14b          6.97
ger14b  ger15b          5.32
```

RELATIVE LE 90% = 39.07

STATISTICS SUMMARY, TAPE ADRI01SP8MM00011 HORIZONTAL ANALYSIS
ALL VALUES IN METERS

ABSOLUTE HORIZONTAL ACCURACY

POINT ID	DELTA LAT	DELTA LON
ger1c	1.36	1.31
ger2c	0.20	-13.56
ger3c	-1.11	-1.51
ger4c	-12.21	11.50
ger5c	6.21	4.70
ger6c	-10.48	4.49
ger7c	-8.43	0.14
ger8c	12.80	12.30
ger9c	-5.81	8.79
ger10c	-4.66	15.00
ger11c	8.42	-2.60
ger12c	-3.66	6.42
ger13c	-3.87	9.01
ger14c	-1.16	8.34
ger15c	-6.95	9.11
ger16c	-7.24	-0.80
ger17c	-4.00	-8.15
ger18c	3.84	12.72
ger19c	-2.99	4.58
ger20c	-1.15	-1.89
ger21c	0.53	21.29
ger22c	-5.89	4.65
ger23c	-5.20	11.64
ger24c	-2.19	5.36
ger25c	9.73	5.02
ger26c	-7.08	1.69
ger27c	-1.28	14.03
ger28c	-7.01	-8.75
ger29c	-17.39	23.93
ger30c	-3.05	14.11

TOTAL NUMBER OF POINTS = 30

90% CIRCULAR ERROR = 18.73

	LAT	LONG
MEAN	-2.66	5.76
SIGMA	6.42	8.44
RMS	6.85	10.10
AVERAGE ERROR	5.53	8.25

HORIZONTAL RELATIVE ACCURACY
TOTAL NUMBER OF POINT PAIR COMBINATIONS = 435

LOW BIN: ALL POINTS LESS THAN 60 KM APART

ID POINT COMBINATION	DELTA DISTANCE
ger1c ger2c	2.91
ger1c ger3c	3.38
ger1c ger4c	2.12
ger1c ger5c	4.06
ger2c ger4c	26.92
ger2c ger5c	3.95
ger3c ger5c	9.29
ger4c ger5c	15.45
ger6c ger10c	10.57
ger7c ger8c	0.63
ger7c ger9c	4.61
ger8c ger9c	16.57
ger11c ger12c	12.86
ger11c ger13c	3.39
ger11c ger14c	10.10
ger11c ger15c	2.28
ger11c ger23c	8.52
ger12c ger13c	1.15
ger12c ger14c	2.96
ger12c ger15c	2.21
ger13c ger14c	2.72
ger14c ger15c	0.97
ger15c ger23c	2.69
ger16c ger17c	4.40
ger16c ger18c	10.42
ger16c ger19c	5.27
ger16c ger20c	1.58
ger17c ger20c	6.89
ger18c ger20c	6.66
ger19c ger20c	5.50
ger21c ger22c	3.70
ger21c ger23c	10.78
ger21c ger24c	0.55
ger21c ger25c	17.95
ger22c ger23c	5.48
ger22c ger24c	3.61
ger22c ger25c	6.69
ger23c ger24c	0.34
ger23c ger25c	15.45
ger24c ger25c	1.11
ger26c ger27c	13.57
ger26c ger28c	8.33
ger26c ger29c	11.22
ger26c ger30c	2.10
ger27c ger28c	21.95
ger27c ger29c	6.47
ger27c ger30c	0.33
ger28c ger29c	34.18
ger28c ger30c	18.?4
ger29c ger30c	5.24

PELATIVE CE 90% = 17.95

HIGH BIN: ALL POINTS GREATER THAN 60 KM APART

ID POINT COMBINATION	DELTA DISTANCE
ger1c ger6c	0.59
ger1c ger7c	2.23
ger1c ger8c	5.67
ger1c ger9c	9.66
ger1c ger10c	13.51
ger1c ger11c	5.25
ger1c ger12c	5.84
ger1c ger13c	8.06
ger1c ger14c	7.19
ger1c ger15c	9.34
ger1c ger16c	7.50
ger1c ger17c	3.56
ger1c ger18c	2.47
ger1c ger19c	5.33
ger1c ger20c	0.56
ger1c ger21c	18.66
ger1c ger22c	5.88
ger1c ger23c	11.50
ger1c ger24c	5.06
ger1c ger25c	0.31
ger1c ger26c	2.97
ger1c ger27c	12.28
ger1c ger28c	6.38
ger1c ger29c	26.97
ger1c ger30c	13.00
ger2c ger3c	1.40
ger2c ger6c	10.06
ger2c ger7c	13.67
ger2c ger8c	24.53
ger2c ger9c	22.97
ger2c ger10c	23.88
ger2c ger11c	10.59
ger2c ger12c	20.16
ger2c ger13c	22.44
ger2c ger14c	21.91
ger2c ger15c	23.12
ger2c ger16c	12.73
ger2c ger17c	5.74
ger2c ger18c	16.08
ger2c ger19c	14.83
ger2c ger20c	9.23
ger2c ger21c	34.19
ger2c ger22c	19.06
ger2c ger23c	25.56
ger2c ger24c	18.66
ger2c ger25c	15.31
ger2c ger26c	16.47
ger2c ger27c	26.62
ger2c ger28c	6.69
ger2c ger29c	40.22
ger2c ger30c	27.31

```
ger3c  ger4c        1.36
ger3c  ger6c        6.08
ger3c  ger7c        5.28
ger3c  ger8c        4.27
ger3c  ger9c       11.05
ger3c  ger10c      16.83
ger3c  ger11c       3.59
ger3c  ger12c       8.28
ger3c  ger13c      10.81
ger3c  ger14c       9.50
ger3c  ger15c      11.84
ger3c  ger16c       6.14
ger3c  ger17c       2.22
ger3c  ger18c       0.94
ger3c  ger19c       4.19
ger3c  ger20c       0.08
ger3c  ger21c      19.25
ger3c  ger22c       7.69
ger3c  ger23c      13.56
ger3c  ger24c       6.22
ger3c  ger25c       0.16
ger3c  ger26c       5.28
ger3c  ger27c      13.72
ger3c  ger28c       3.88
ger3c  ger29c      29.16
ger3c  ger30c      14.75
 ger4c  ger6c       5.83
 ger4c  ger7c      11.42
 ger4c  ger8c       4.33
 ger4c  ger9c       3.95
ger4c  ger10c       5.11
ger4c  ger11c      15.56
ger4c  ger12c       5.34
ger4c  ger13c       1.97
ger4c  ger14c       3.34
ger4c  ger15c       2.47
ger4c  ger16c      10.86
ger4c  ger17c      15.69
ger4c  ger18c      10.27
ger4c  ger19c      11.28
ger4c  ger20c      17.06
ger4c  ger21c       6.88
ger4c  ger22c       7.88
ger4c  ger23c       0.56
ger4c  ger24c       8.81
ger4c  ger25c      12.56
ger4c  ger26c       9.75
ger4c  ger27c       0.25
ger4c  ger28c      19.44
ger4c  ger29c      13.88
ger4c  ger30c       0.69
 ger5c  ger6c       3.66
 ger5c  ger7c       0.80
 ger5c  ger8c       4.91
```

```
ger5c  ger9c        7.66
ger5c  ger10c       9.55
ger5c  ger11c       7.97
ger5c  ger12c       2.91
ger5c  ger13c       4.62
ger5c  ger14c       4.09
ger5c  ger15c       6.53
ger5c  ger16c       9.03
ger5c  ger17c       4.86
ger5c  ger18c       6.67
ger5c  ger19c       6.78
ger5c  ger20c       1.30
ger5c  ger21c      16.88
ger5c  ger22c       3.88
ger5c  ger23c       8.94
ger5c  ger24c       3.62
ger5c  ger25c       1.44
ger5c  ger26c       0.56
ger5c  ger27c      10.34
ger5c  ger28c       8.81
ger5c  ger29c      24.56
ger5c  ger30c      10.81
 ger6c  ger7c       2.85
 ger6c  ger8c      18.08
 ger6c  ger9c       2.60
ger6c  ger11c      13.72
ger6c  ger12c       0.67
ger6c  ger13c       3.03
ger6c  ger14c       0.83
ger6c  ger15c       2.56
ger6c  ger16c       1.11
ger6c  ger17c       0.70
ger6c  ger18c      16.30
ger6c  ger19c       7.41
ger6c  ger20c       7.67
ger6c  ger21c       4.61
ger6c  ger22c       3.16
ger6c  ger23c       3.02
ger6c  ger24c       5.80
ger6c  ger25c      13.50
ger6c  ger26c       3.50
ger6c  ger27c       3.31
ger6c  ger28c      12.25
ger6c  ger29c      20.09
ger6c  ger30c       5.00
ger7c  ger10c       4.25
ger7c  ger11c       3.70
ger7c  ger12c       6.03
ger7c  ger13c       9.47
ger7c  ger14c       8.19
ger7c  ger15c       8.88
ger7c  ger16c       0.25
ger7c  ger17c       2.20
ger7c  ger18c      16.96
```

```
ger7c  ger19c          6.61
ger7c  ger20c          5.17
ger7c  ger21c         16.79
ger7c  ger22c          2.86
ger7c  ger23c         10.69
ger7c  ger24c          0.69
ger7c  ger25c          4.16
ger7c  ger26c          1.53
ger7c  ger27c         10.31
ger7c  ger28c          8.06
ger7c  ger29c         25.41
ger7c  ger30c         11.59
ger8c  ger10c         15.34
ger8c  ger11c         15.36
ger8c  ger12c          5.77
ger8c  ger13c          5.88
ger8c  ger14c          4.80
ger8c  ger15c          2.11
ger8c  ger16c         22.45
ger8c  ger17c         26.08
ger8c  ger18c          2.32
ger8c  ger19c         17.20
ger8c  ger20c         19.72
ger8c  ger21c         11.74
ger8c  ger22c          1.67
ger8c  ger23c          1.37
ger8c  ger24c          3.16
ger8c  ger25c          5.38
ger8c  ger26c          4.97
ger8c  ger27c          5.75
ger8c  ger28c         14.00
ger8c  ger29c         20.00
ger8c  ger30c          5.69
ger9c  ger10c          2.95
ger9c  ger11c          9.97
ger9c  ger12c          2.11
ger9c  ger13c          0.86
ger9c  ger14c          0.19
ger9c  ger15c          0.48
ger9c  ger16c          8.89
ger9c  ger17c         13.17
ger9c  ger18c          5.79
ger9c  ger19c          0.89
ger9c  ger20c          5.96
ger9c  ger21c         11.40
ger9c  ger22c          3.74
ger9c  ger23c          2.95
ger9c  ger24c          4.81
ger9c  ger25c          9.61
ger9c  ger26c          6.19
ger9c  ger27c          3.50
ger9c  ger28c         15.84
ger9c  ger29c         17.91
ger9c  ger30c          4.41
```

```
ger10c ger11c        20.44
ger10c ger12c         8.38
ger10c ger13c         5.88
ger10c ger14c         7.19
ger10c ger15c         4.61
ger10c ger16c         7.56
ger10c ger17c         8.48
ger10c ger18c         6.34
ger10c ger19c         0.98
ger10c ger20c         0.78
ger10c ger21c         2.17
ger10c ger22c         7.28
ger10c ger23c         2.81
ger10c ger24c         8.75
ger10c ger25c        16.58
ger10c ger26c        10.88
ger10c ger27c         2.56
ger10c ger28c        19.84
ger10c ger29c        13.25
ger10c ger30c         1.59
ger11c ger16c         2.69
ger11c ger17c         8.72
ger11c ger18c        14.84
ger11c ger19c         2.78
ger11c ger20c         1.72
ger11c ger21c        20.21
ger11c ger22c         1.48
ger11c ger24c         1.45
ger11c ger25c         5.20
ger11c ger26c        11.83
ger11c ger27c        18.48
ger11c ger28c         3.41
ger11c ger29c        36.23
ger11c ger30c        19.83
ger12c ger16c         8.09
ger12c ger17c        14.16
ger12c ger18c         6.78
ger12c ger19c         1.78
ger12c ger20c         7.59
ger12c ger21c        15.23
ger12c ger22c         2.58
ger12c ger23c         4.91
ger12c ger24c         0.20
ger12c ger25c         7.89
ger12c ger26c         1.89
ger12c ger27c         3.58
ger12c ger28c        10.25
ger12c ger29c        21.95
ger12c ger30c         5.72
ger13c ger15c         1.79
ger13c ger16c        10.56
ger13c ger17c        16.12
ger13c ger18c         4.81
ger13c ger19c         4.00
```

```
ger13c ger20c        9.53
ger13c ger21c       12.73
ger13c ger22c        4.91
ger13c ger23c        1.62
ger13c ger24c        1.86
ger13c ger25c        7.32
ger13c ger26c        2.52
ger13c ger27c        0.31
ger13c ger28c        9.81
ger13c ger29c       19.44
ger13c ger30c        2.56
ger14c ger16c       10.53
ger14c ger17c       16.50
ger14c ger18c        4.84
ger14c ger19c        4.31
ger14c ger20c        9.91
ger14c ger21c       12.83
ger14c ger22c        5.36
ger14c ger23c        2.21
ger14c ger24c        3.16
ger14c ger25c        4.38
ger14c ger26c        0.94
ger14c ger27c        3.33
ger14c ger28c        8.77
ger14c ger29c       22.17
ger14c ger30c        5.28
ger15c ger16c        9.91
ger15c ger17c       15.78
ger15c ger18c        4.28
ger15c ger19c        3.28
ger15c ger20c        9.41
ger15c ger21c       13.28
ger15c ger22c        3.48
ger15c ger24c        0.41
ger15c ger25c       12.70
ger15c ger26c        6.34
ger15c ger27c        0.62
ger15c ger28c       15.22
ger15c ger29c       17.91
ger15c ger30c        2.45
ger16c ger21c       23.89
ger16c ger22c        5.91
ger16c ger23c       12.94
ger16c ger24c        6.91
ger16c ger25c        7.81
ger16c ger26c        3.06
ger16c ger27c       14.91
ger16c ger28c        7.25
ger16c ger29c       25.72
ger16c ger30c       15.25
ger17c ger18c       13.34
ger17c ger19c       12.77
ger17c ger21c       29.75
ger17c ger22c       12.19
```

```
ger17c ger23c        18.75
ger17c ger24c        13.83
ger17c ger25c        15.19
ger17c ger26c        10.19
ger17c ger27c        22.38
ger17c ger28c         0.06
ger17c ger29c        32.66
ger17c ger30c        22.56
ger18c ger19c         0.55
ger18c ger21c         8.23
ger18c ger22c         7.86
ger18c ger23c         2.06
ger18c ger24c         6.62
ger18c ger25c         8.47
ger18c ger26c         9.75
ger18c ger27c         1.75
ger18c ger28c        19.47
ger18c ger29c        14.00
ger18c ger30c         1.94
ger19c ger21c        17.09
ger19c ger22c         0.56
ger19c ger23c         6.03
ger19c ger24c         0.98
ger19c ger25c         2.23
ger19c ger26c         2.56
ger19c ger27c         9.47
ger19c ger28c        12.69
ger19c ger29c        20.25
ger19c ger30c         9.72
ger20c ger21c        22.95
ger20c ger22c         5.78
ger20c ger23c        12.06
ger20c ger24c         7.23
ger20c ger25c         7.45
ger20c ger26c         4.06
ger20c ger27c        15.81
ger20c ger28c         6.03
ger20c ger29c        27.19
ger20c ger30c        16.09
ger21c ger26c        16.41
ger21c ger27c         6.20
ger21c ger28c        25.56
ger21c ger29c         8.50
ger21c ger30c         5.86
ger22c ger26c         2.38
ger22c ger27c         7.55
ger22c ger28c        12.19
ger22c ger29c        21.69
ger22c ger30c         8.56
ger23c ger26c         8.31
ger23c ger27c         0.09
ger23c ger28c        17.44
ger23c ger29c        16.23
ger23c ger30c         1.34
```

```
ger24c ger26c        2.86
ger24c ger27c        8.22
ger24c ger28c       12.69
ger24c ger29c       21.03
ger24c ger30c        8.77
ger25c ger26c        0.62
ger25c ger27c       11.30
ger25c ger28c        9.64
ger25c ger29c       24.39
ger25c ger30c       11.06
```

RELATIVE CE 90% = 20.00

STATISTICS SUMMARY, TAPE ADRI01SP8MM00011 VERTICAL ANALYSIS
ALL VALUES IN METERS

ABSOLUTE VERTICAL ACCURACY

POINT ID   DELTA HEIGHT

       ger1c   -42.70
       ger2c   -46.76
       ger3c   -39.84
       ger4c   -37.52
       ger5c   -41.42
       ger6c   -8.28
       ger7c   -31.73
       ger8c   -36.25
       ger9c   -20.33
      ger10c   -45.69
      ger11c   -39.11
      ger12c   -40.90
      ger13c   -45.50
      ger14c   -46.96
      ger15c   -35.90
      ger16c   -53.86
      ger17c   -51.35
      ger18c   -81.85
      ger19c   -116.95
      ger20c   -50.70
      ger21c   -32.35
      ger22c   -54.75
      ger23c   -42.45
      ger24c   -29.35
      ger25c   -40.85
      ger26c   -45.87
      ger27c   -50.88
      ger28c   -22.19
      ger29c   -33.72
      ger30c   -55.65

  NUMBER OF POINTS = 30

     90% LINEAR ERROR =   68.37
        MEAN   -44.06
       SIGMA   18.97
         RMS   47.84
 AVERAGE ERROR   44.06

          VERTICAL RELATIVE ACCURACY
TOTAL NUMBER OF POINT PAIR COMBINATIONS = 435

LOW BIN: ALL POINTS LESS THAN 60 KM APART

```
ID POINT COMBINATION          DELTA HEIGHT
          ger1c ger2c              4.06
          ger1c ger3c              2.86
          ger1c ger4c              5.18
          ger1c ger5c              1.28
          ger2c ger4c              9.24
          ger2c ger5c              5.34
          ger3c ger5c              1.58
          ger4c ger5c              3.90
         ger6c ger10c             37.41
          ger7c ger8c              4.52
          ger7c ger9c             11.40
          ger8c ger9c             15.92
        ger11c ger12c              1.79
        ger11c ger13c              6.39
        ger11c ger14c              7.85
        ger11c ger15c              3.21
        ger11c ger23c              3.34
        ger12c ger13c              4.60
        ger12c ger14c              6.06
        ger12c ger15c              5.00
        ger13c ger14c              1.46
        ger14c ger15c             11.06
        ger15c ger23c              6.55
        ger16c ger17c              2.51
        ger16c ger18c             27.99
        ger16c ger19c             63.09
        ger16c ger20c              3.16
        ger17c ger20c              0.65
        ger18c ger20c             31.15
        ger19c ger20c             66.25
        ger21c ger22c             22.40
        ger21c ger23c             10.10
        ger21c ger24c              3.00
        ger21c ger25c              8.50
        ger22c ger23c             12.30
        ger22c ger24c             25.40
        ger22c ger25c             13.90
        ger23c ger24c             13.10
        ger23c ger25c              1.60
        ger24c ger25c             11.50
        ger26c ger27c              5.02
        ger26c ger28c             23.68
        ger26c ger29c             12.14
        ger26c ger30c              9.78
        ger27c ger28c             28.69
        ger27c ger29c             17.16
        ger27c ger30c              4.76
        ger28c ger29c             11.53
        ger28c ger30c             33.46
        ger29c ger30c             21.92

     RELATIVE LE 90% = 31.15
```

HIGH BIN: ALL POINTS GREATER THAN 60 KM APART

ID POINT COMBINATION	DELTA HEIGHT
ger1c ger6c	34.42
ger1c ger7c	10.97
ger1c ger8c	6.45
ger1c ger9c	22.37
ger1c ger10c	2.99
ger1c ger11c	3.59
ger1c ger12c	1.80
ger1c ger13c	2.80
ger1c ger14c	4.26
ger1c ger15c	6.80
ger1c ger16c	11.16
ger1c ger17c	8.65
ger1c ger18c	39.15
ger1c ger19c	74.25
ger1c ger20c	8.00
ger1c ger21c	10.35
ger1c ger22c	12.05
ger1c ger23c	0.25
ger1c ger24c	13.35
ger1c ger25c	1.85
ger1c ger26c	3.17
ger1c ger27c	8.18
ger1c ger28c	20.51
ger1c ger29c	8.98
ger1c ger30c	12.95
ger2c ger3c	6.92
ger2c ger6c	38.47
ger2c ger7c	15.03
ger2c ger8c	10.51
ger2c ger9c	26.42
ger2c ger10c	1.07
ger2c ger11c	7.65
ger2c ger12c	5.86
ger2c ger13c	1.26
ger2c ger14c	0.20
ger2c ger15c	10.86
ger2c ger16c	7.10
ger2c ger17c	4.59
ger2c ger18c	35.09
ger2c ger19c	70.19
ger2c ger20c	3.94
ger2c ger21c	14.41
ger2c ger22c	7.99
ger2c ger23c	4.31
ger2c ger24c	17.41
ger2c ger25c	5.91
ger2c ger26c	0.89
ger2c ger27c	4.13
ger2c ger28c	24.57
ger2c ger29c	13.04
ger2c ger30c	8.89

```
ger3c  ger4c        2.32
ger3c  ger6c       31.56
ger3c  ger7c        8.11
ger3c  ger8c        3.59
ger3c  ger9c       19.51
ger3c  ger10c       5.85
ger3c  ger11c       0.73
ger3c  ger12c       1.06
ger3c  ger13c       5.66
ger3c  ger14c       7.12
ger3c  ger15c       3.94
ger3c  ger16c      14.02
ger3c  ger17c      11.51
ger3c  ger18c      42.01
ger3c  ger19c      77.11
ger3c  ger20c      10.86
ger3c  ger21c       7.49
ger3c  ger22c      14.91
ger3c  ger23c       2.61
ger3c  ger24c      10.49
ger3c  ger25c       1.01
ger3c  ger26c       6.02
ger3c  ger27c      11.04
ger3c  ger28c      17.65
ger3c  ger29c       6.12
ger3c  ger30c      15.80
 ger4c  ger6c      29.24
 ger4c  ger7c       5.79
 ger4c  ger8c       1.27
 ger4c  ger9c      17.19
ger4c  ger10c       8.17
ger4c  ger11c       1.59
ger4c  ger12c       3.38
ger4c  ger13c       7.98
ger4c  ger14c       9.44
ger4c  ger15c       1.62
ger4c  ger16c      16.34
ger4c  ger17c      13.83
ger4c  ger18c      44.33
ger4c  ger19c      79.43
ger4c  ger20c      13.18
ger4c  ger21c       5.17
ger4c  ger22c      17.23
ger4c  ger23c       4.93
ger4c  ger24c       8.17
ger4c  ger25c       3.33
ger4c  ger26c       8.35
ger4c  ger27c      13.37
ger4c  ger28c      15.33
ger4c  ger29c       3.80
ger4c  ger30c      18.13
 ger5c  ger6c      33.13
 ger5c  ger7c       9.69
 ger5c  ger8c       5.17
```

```
ger5c ger9c        21.08
ger5c ger10c        4.27
ger5c ger11c        2.31
ger5c ger12c        0.52
ger5c ger13c        4.08
ger5c ger14c        5.55
ger5c ger15c        5.52
ger5c ger16c       12.45
ger5c ger17c        9.93
ger5c ger18c       40.43
ger5c ger19c       75.53
ger5c ger20c        9.28
ger5c ger21c        9.07
ger5c ger22c       13.33
ger5c ger23c        1.03
ger5c ger24c       12.07
ger5c ger25c        0.57
ger5c ger26c        4.45
ger5c ger27c        9.47
ger5c ger28c       19.23
ger5c ger29c        7.70
ger5c ger30c       14.23
 ger6c ger7c       23.45
 ger6c ger8c       27.97
 ger6c ger9c       12.05
ger6c ger11c       30.83
ger6c ger12c       32.62
ger6c ger13c       37.22
ger6c ger14c       38.68
ger6c ger15c       27.62
ger6c ger16c       45.58
ger6c ger17c       43.07
ger6c ger18c       73.57
ger6c ger19c      108.67
ger6c ger20c       42.42
ger6c ger21c       24.07
ger6c ger22c       46.47
ger6c ger23c       34.17
ger6c ger24c       21.07
ger6c ger25c       32.57
ger6c ger26c       37.58
ger6c ger27c       42.60
ger6c ger28c       13.91
ger6c ger29c       25.44
ger6c ger30c       47.36
ger7c ger10c       13.96
ger7c ger11c        7.38
ger7c ger12c        9.17
ger7c ger13c       13.77
ger7c ger14c       15.23
ger7c ger15c        4.17
ger7c ger16c       22.13
ger7c ger17c       19.62
ger7c ger18c       50.12
```

```
ger7c  ger19c      85.22
ger7c  ger20c      18.97
ger7c  ger21c       0.62
ger7c  ger22c      23.02
ger7c  ger23c      10.72
ger7c  ger24c       2.38
ger7c  ger25c       9.12
ger7c  ger26c      14.14
ger7c  ger27c      19.15
ger7c  ger28c       9.54
ger7c  ger29c       1.99
ger7c  ger30c      23.92
ger8c  ger10c       9.44
ger8c  ger11c       2.86
ger8c  ger12c       4.65
ger8c  ger13c       9.25
ger8c  ger14c      10.71
ger8c  ger15c       0.35
ger8c  ger16c      17.61
ger8c  ger17c      15.10
ger8c  ger18c      45.60
ger8c  ger19c      80.70
ger8c  ger20c      14.45
ger8c  ger21c       3.90
ger8c  ger22c      18.50
ger8c  ger23c       6.20
ger8c  ger24c       6.90
ger8c  ger25c       4.60
ger8c  ger26c       9.62
ger8c  ger27c      14.63
ger8c  ger28c      14.06
ger8c  ger29c       2.53
ger8c  ger30c      19.40
ger9c  ger10c      25.36
ger9c  ger11c      18.78
ger9c  ger12c      20.57
ger9c  ger13c      25.17
ger9c  ger14c      26.63
ger9c  ger15c      15.57
ger9c  ger16c      33.53
ger9c  ger17c      31.02
ger9c  ger18c      61.52
ger9c  ger19c      96.62
ger9c  ger20c      30.37
ger9c  ger21c      12.02
ger9c  ger22c      34.42
ger9c  ger23c      22.12
ger9c  ger24c       9.02
ger9c  ger25c      20.52
ger9c  ger26c      25.53
ger9c  ger27c      30.55
ger9c  ger28c       1.86
ger9c  ger29c      13.39
ger9c  ger30c      35.31
```

```
ger10c ger11c          6.58
ger10c ger12c          4.79
ger10c ger13c          0.19
ger10c ger14c          1.27
ger10c ger15c          9.79
ger10c ger16c          8.17
ger10c ger17c          5.66
ger10c ger18c         36.16
ger10c ger19c         71.26
ger10c ger20c          5.01
ger10c ger21c         13.34
ger10c ger22c          9.06
ger10c ger23c          3.24
ger10c ger24c         16.34
ger10c ger25c          4.84
ger10c ger26c          0.17
ger10c ger27c          5.19
ger10c ger28c         23.50
ger10c ger29c         11.97
ger10c ger30c          9.96
ger11c ger16c         14.75
ger11c ger17c         12.24
ger11c ger18c         42.74
ger11c ger19c         77.84
ger11c ger20c         11.59
ger11c ger21c          6.76
ger11c ger22c         15.64
ger11c ger24c          9.76
ger11c ger25c          1.74
ger11c ger26c          6.76
ger11c ger27c         11.77
ger11c ger28c         16.92
ger11c ger29c          5.39
ger11c ger30c         16.54
ger12c ger16c         12.96
ger12c ger17c         10.45
ger12c ger18c         40.95
ger12c ger19c         76.05
ger12c ger20c          9.80
ger12c ger21c          8.55
ger12c ger22c         13.85
ger12c ger23c          1.55
ger12c ger24c         11.55
ger12c ger25c          0.05
ger12c ger26c          4.97
ger12c ger27c          9.98
ger12c ger28c         18.71
ger12c ger29c          7.18
ger12c ger30c         14.75
ger13c ger15c          9.60
ger13c ger16c          8.36
ger13c ger17c          5.85
ger13c ger18c         36.35
ger13c ger19c         71.45
```

```
ger13c ger20c        5.20
ger13c ger21c       13.15
ger13c ger22c        9.25
ger13c ger23c        3.05
ger13c ger24c       16.15
ger13c ger25c        4.65
ger13c ger26c        0.37
ger13c ger27c        5.38
ger13c ger28c       23.31
ger13c ger29c       11.78
ger13c ger30c       10.15
ger14c ger16c        6.90
ger14c ger17c        4.39
ger14c ger18c       34.89
ger14c ger19c       69.99
ger14c ger20c        3.74
ger14c ger21c       14.61
ger14c ger22c        7.79
ger14c ger23c        4.51
ger14c ger24c       17.61
ger14c ger25c        6.11
ger14c ger26c        1.10
ger14c ger27c        3.92
ger14c ger28c       24.77
ger14c ger29c       13.24
ger14c ger30c        8.68
ger15c ger16c       17.96
ger15c ger17c       15.45
ger15c ger18c       45.95
ger15c ger19c       81.05
ger15c ger20c       14.80
ger15c ger21c        3.55
ger15c ger22c       18.85
ger15c ger24c        6.55
ger15c ger25c        4.95
ger15c ger26c        9.97
ger15c ger27c       14.98
ger15c ger28c       13.71
ger15c ger29c        2.18
ger15c ger30c       19.75
ger16c ger21c       21.51
ger16c ger22c        0.89
ger16c ger23c       11.41
ger16c ger24c       24.51
ger16c ger25c       13.01
ger16c ger26c        8.00
ger16c ger27c        2.98
ger16c ger28c       31.67
ger16c ger29c       20.14
ger16c ger30c        1.78
ger17c ger18c       30.50
ger17c ger19c       65.60
ger17c ger21c       19.00
ger17c ger22c        3.40
```

```
ger17c ger23c      8.90
ger17c ger24c     22.00
ger17c ger25c     10.50
ger17c ger26c      5.48
ger17c ger27c      0.47
ger17c ger28c     29.16
ger17c ger29c     17.63
ger17c ger30c      4.30
ger18c ger19c     35.10
ger18c ger21c     49.50
ger18c ger22c     27.10
ger18c ger23c     39.40
ger18c ger24c     52.50
ger18c ger25c     41.00
ger18c ger26c     35.98
ger18c ger27c     30.97
ger18c ger28c     59.66
ger18c ger29c     48.13
ger18c ger30c     26.20
ger19c ger21c     84.60
ger19c ger22c     62.20
ger19c ger23c     74.50
ger19c ger24c     87.60
ger19c ger25c     76.10
ger19c ger26c     71.08
ger19c ger27c     66.07
ger19c ger28c     94.76
ger19c ger29c     83.23
ger19c ger30c     61.30
ger20c ger21c     18.35
ger20c ger22c      4.05
ger20c ger23c      8.25
ger20c ger24c     21.35
ger20c ger25c      9.85
ger20c ger26c      4.83
ger20c ger27c      0.18
ger20c ger28c     28.51
ger20c ger29c     16.98
ger20c ger30c      4.95
ger21c ger26c     13.52
ger21c ger27c     18.53
ger21c ger28c     10.16
ger21c ger29c      1.37
ger21c ger30c     23.30
ger22c ger26c      8.88
ger22c ger27c      3.87
ger22c ger28c     32.56
ger22c ger29c     21.03
ger22c ger30c      0.90
ger23c ger26c      3.42
ger23c ger27c      8.43
ger23c ger28c     20.26
ger23c ger29c      8.73
ger23c ger30c     13.20
```

```
ger24c ger26c          16.52
ger24c ger27c          21.53
ger24c ger28c           7.16
ger24c ger29c           4.37
ger24c ger30c          26.30
ger25c ger26c           5.02
ger25c ger27c          10.03
ger25c ger28c          18.66
ger25c ger29c           7.13
ger25c ger30c          14.80
```

RELATIVE LE 90% = 45.58